

# Debt, Equity, and Information

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## Abstract

Straight debt and outside equity are the most fundamental types of financial securities. Yet, the diversity of outside claims has received little attention. This paper answers the question of why debt and equity are optimal instead of other forms of financial contracts. It simultaneously rationalizes the following stylized facts: (i) equity carries state-contingent cash flow rights, while debt-holders' cash flow rights are state-independent outside of bankruptcy; (ii) equity carries unconditional monitoring rights, while debt-holders' monitoring rights are contingent on bankruptcy; (iii) equity serves as an incentive contract that alleviates managerial moral hazard by inducing endogenous dividend signaling; (iv) equity financing prevails when companies have a large growth potential and relatively risky cash flows, and when a credible information policy to outside investors is cost-efficient to implement (e.g. good corporate governance or small firm size).

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# 1 Introduction

There is a large literature on financial contracting that considers deals between financiers and those who need financing. The key insight from a security design perspective is: contingent on model assumptions optimal contracts are either debt- *or* equity-like.<sup>1</sup> Almost all papers that consider debt *and* outside equity focus on questions unrelated to security design — securities' characteristics are exogenously specified. In this sense, diversity of outside claims has received little attention.<sup>2</sup>

Yet, we are living in a world in which diversity of outside claims clearly matters. Debt and equity are the most fundamental types of financial securities. As a consequence, it is important to understand why these and not other forms of contracts are optimal.

This paper shows how straight debt and outside equity obtain when contracts are endogenously incomplete. It simultaneously rationalizes the following stylized facts: (i) equity carries state-contingent cash flow rights, while debt-holders' cash flow rights are state-independent outside of bankruptcy; (ii) equity carries unconditional monitoring rights, while debt-holders' monitoring rights are contingent on bankruptcy; (iii) equity serves as an incentive contract that alleviates managerial moral hazard by inducing endogenous dividend signaling; (iv) equity financing prevails when companies have a large growth potential and relatively risky cash flows, and when a credible information policy to outside investors is cost-efficient to implement (e.g. good corporate governance or small firm size).

Endogenous incompleteness of contracts obtains as follows. There are two agents, an outside investor with deep pockets and a penniless entrepreneur with an investment project. After the project's cash flow realization, the entrepreneur may make a payout to the investor. Agents anticipate that they cannot commit to their contract over the long run. That is, agents anticipate *ex ante* that they will renegotiate the contract after the payout of the entrepreneur. As a consequence, agents choose not to contract on the payout *ex ante*. Renegotiation is important because bankruptcy is costly. Since agents have incentives to avoid bankruptcy, renegotiation improves *ex post* efficiency.

The economic intuition behind this paper's result is as follows. Consider two cases, a start-up company with venture capital financing and a mature company with a large investor. Begin with the start-up. Since the company has a large growth potential, the venture capitalist expects that the company performs well. As a consequence, she obtains state-contingent cash flow rights to capitalize on her expectation of a large cash flow realization. Since cash flows are relatively risky, the venture capitalist has incentives to hold monitoring rights: potential cash flow realizations are far apart, and therefore it is important to find out how the company performs. Since the company

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<sup>1</sup>See Townsend (1979), Diamond (1984), Gale and Hellwig (1985), Aghion and Bolton (1992), and Krasa and Villamil (2000).

<sup>2</sup>Notable exceptions include Dewatripont and Tirole (1994) and Berglöf and von Thadden (1994).

is small and a credible information policy is cost-efficient to implement, it is optimal to assign unconditional monitoring rights. As a consequence, the optimal contract is equity.

In contrast to the start-up, the old and mature company has a low growth potential and its cash flows are relatively stable. Since firm size is large and corporate governance is involved, the investor shies away from monitoring because it is costly. She reasons that monitoring will probably not make a difference: she does not expect the company to surprise with a large jump in revenue since cash flows are stable. As a consequence, the investor is willing to hold securities that have state-independent cash flow rights outside of bankruptcy. Since she knows *ex ante* that she is not willing to monitor *ex post*, she is content with a contract that does not carry monitoring rights outside of bankruptcy. As a consequence, the optimal contract is debt.

The key difference between this paper and most of the previous literature<sup>3</sup> is the following: this paper relaxes the assumption of perfect *ex-post* enforcement of contracts through an exogenous unmodeled authority. As a consequence, firm liquidation is endogenous along two dimension. First, the act of initiating bankruptcy takes place in a choice-theoretic framework. Once the investor decides to liquidate, the court resolves potentially asymmetric information and transfers the enforceable payment from the entrepreneur to the investor. In this sense, bankruptcy corresponds to the investor taking control of the firm and seizing assets. Second, the enforceable payment itself is endogenous: agents write a contract that specifies a potentially state-contingent enforceable payment. This approach is important for two reasons. First, the enforceable payment induces cash flow rights. Second, it serves as an incentive contract to alleviate managerial moral hazard. Under equity control, the liquidation threat incentivizes the entrepreneur to signal private information through his payout policy.

The rest of this paper is organized as follows. Section 2 introduces and motivates the model. Section 3 solves the model. Section 4 shows how the model relates to debt and equity and derives empirical predictions. Section 5 concludes and the Appendix contains mathematical proofs.

**Related Literature** In the spirit of this paper, Dewatripont and Tirole (1994) consider the diversity of outside claims. Outside investors' control rights are about whether to stop or to continue the entrepreneur's investment project. Control rights serve as an incentive scheme for the entrepreneur to exert unobservable effort. Income rights serve as an incentive scheme for outsiders who have control. Dewatripont and Tirole require several investors since one investor needs to be the residual claimant of the

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<sup>3</sup>Prior research interprets bankruptcy as a bad signal about the state of nature and the resulting transfer of control (see Aghion and Bolton (1992)), a low payout (see Diamond (1984)), the act of verification (see Townsend (1979) and Gale and Hellwig (1985)), or the intervention of outside investors in management (see Dewatripont and Tirole (1994)). This paper's view that bankruptcy is a decision variable is in the spirit of Krasa and Villamil (2000).

incentive scheme on income rights. Their main result is that bad performance implies debt-holder control, which yields a bias for stopping the investment project. As a consequence, there is managerial fear towards creditors. Vice versa, good performance implies equity-holder control, which yields a bias for continuing the project. In this sense, there is a congruence between managerial and (passive) shareholders' interests. In contrast to Dewatripont and Tirole, this paper focuses on monitoring rights when information is not necessarily symmetric.

Krasa and Villamil (2000) and this paper both view bankruptcy as a decision variable by considering enforcement as a decision variable. Krasa and Villamil focus on ex post asymmetric information. Their main result is that simple debt is the optimal contract when agents can renegotiate ex post. In contrast to Krasa and Villamil, this paper allows for unconditional monitoring rights, that is, monitoring outside of bankruptcy.

Aghion and Bolton (1992) relate to this paper by focusing on incomplete contracts. Aghion and Bolton consider shifts in control under symmetric information. Control rights pertain to an action that influences the stochastic return of an investment project. After financing the project, both the outside investor and the entrepreneur observe a verifiable signal about the state of nature. When the signal is bad, the investor takes control. The entrepreneur retains control when the signal is good. This result explains the control rights of debt. In contrast to Aghion and Bolton, this paper considers bankruptcy in a choice-theoretic framework.

## 2 The Model

Consider two risk neutral agents, an investor with deep pockets (“she”) and a penniless entrepreneur (“he”). The entrepreneur has an investment opportunity and needs outside financing. To finance the project, the investor proposes a contract that the entrepreneur can accept or reject.<sup>4</sup> The investor finances the project only if the entrepreneur accepts. The project expires worthless if the entrepreneur rejects. Ex ante, both agents share a common prior<sup>5</sup>

$$\beta := P(X = x_H) \in (0, 1)$$

about the project’s cash flow  $X \in \{x_L, x_H\}$ , where  $x_L < x_H$ . The common prior  $\beta$  represents agents’ belief about the growth potential of the company. After the contract is signed, nature makes a draw and determines the project’s cash flow realization  $x$ . An informational asymmetry arises: the entrepreneur observes the project’s cash flow, but the investor does not.

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<sup>4</sup>This approach is in the spirit of Bolton and Scharfstein (1990) and Kaplan and Strömberg (2003).

<sup>5</sup> $P$  is the probability measure from the game’s underlying probability space  $(\Omega, \mathcal{F}, P)$ . Using standard notation, an upper-case symbol denotes a random variable and a lower-case symbol denotes a random variable’s realization.  $P(X = x)$  is shorthand for  $P(\{X = x\})$ , where  $\{X = x\} := \{\omega \in \Omega \mid X(\omega) = x\}$  denotes the event that the realization  $x$  occurred.

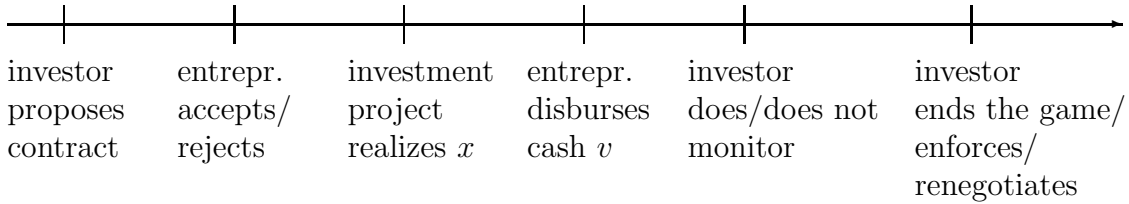


Figure 1: Timeline

After the realization  $x$  of the cash flow, the entrepreneur has the opportunity to signal his private information by paying out parts of the cash flow. The payout  $v \geq 0$  is voluntary and represents money on the table that cannot be withdrawn subsequently. Either the entrepreneur reveals (signals) the project's cash flow realization, or he conceals (pools) his payout, or he plays a mixed strategy. The investor receives the payout  $v$  and updates her belief about the project according to Bayes' rule to

$$\beta_v := P(X = x_H | V = v).$$

She conditions on the event  $\{V = v\}$ , where the conditional distribution of the random variable  $V|X = x_E$  represents the entrepreneur's payout strategy for  $E \in \{L, H\}$ .

The contract may carry monitoring rights. In that case, the investor chooses whether or not to monitor the entrepreneur's project. *Monitoring* pertains to hidden information. If the investor monitors, she subsequently knows the cash flow realization. Monitoring is costly for the investor; monitoring costs are  $c > 0$ . At the time the investor makes her monitoring decision, her information is in one of two states: (i) The investor is informed because of the signal contained in the entrepreneur's payout. That is, only one entrepreneur type<sup>6</sup> makes the payout observed by the investor with positive probability. (ii) The investor is uninformed since the payout that she observed is made by both types with positive probability. Her belief about the project's cash flow realization is strictly between zero and one.

After her monitoring decision the investor chooses one of the following: (i) she ends the game, (ii) she initiates bankruptcy proceedings and takes the entrepreneur to court ("enforcement"), or (iii) she renegotiates the original contract. The first case accounts for the possibility that the investor is content with the payout she received. The second and third case account for the possibility that the payout is too low, leaving the investor unsatisfied. Figure 1 summarizes the timeline.

Enforcement resolves potentially asymmetric information: the court identifies the project's cash flow realization, transfers the *enforceable payment* from the entrepreneur to the investor, and ends the game. The enforceable payment depends on the contract

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<sup>6</sup>I refer to the *type* of the entrepreneur in the ex post sense. That is, the ex post move by nature that determines the cash flow realization  $x_E \in \{x_L, x_H\}$  also determines the entrepreneur's type  $E \in \{L, H\}$ .

and is subject to limited liability of the entrepreneur. The contract endogenously conditions on the cash flow realization, so the enforceable payment potentially depends on the project’s cash flow as well. Enforcement is costly for both agents. If the investor decides to take the entrepreneur to court, each agent incurs bankruptcy costs  $b > 0$  that represent legal fees and expenses.<sup>7</sup> Overall bankruptcy costs  $2b$  are larger than monitoring costs  $c$  for the following reason. Identifying the cash flow realization is identical to monitoring. Additionally, the court makes a transfer payment.

The possibility of enforcement is independent of whether the contract carries monitoring rights. Even the investor who does not have monitoring rights can initiate bankruptcy proceedings. He resolves asymmetric information by using the court as a monitor. In this sense, the *monitoring rights* stipulated by the contract refer to monitoring outside of bankruptcy. The key differences between monitoring and enforcement are: (i) monitoring does not necessarily end the game, but enforcement does and (ii) monitoring does not entail a transfer payment, but enforcement does. The first difference implies that the investor can use the information obtained by monitoring to optimize over subsequent choices. If the investor enforces, she forgoes this opportunity.

Renegotiation is similar in spirit to Rubinstein bargaining (see Rubinstein (1982) and Rubinstein (1985)). The key differences are that (i) only the investor makes requests and (ii) enforcement is possible in each round. Renegotiation consists of an infinite number of rounds where later rounds are being discounted (“time” is valuable). Time costs ensure that agents prefer early agreements by depriving them of incentives to play waiting games.

In each round, the investor makes a request for a payout. The entrepreneur accepts or rejects. If he accepts, he makes the requested payout and the game ends. If he rejects, the investor updates her belief about the cash flow realization according to Bayes’ rule. Using her posterior belief, the investor decides whether to enforce or to continue. Enforcement proceeds as described in the previous paragraph. The game ends after enforcement. If the investor continues, she initiates a subsequent round of renegotiation. Figure 2 shows one round of renegotiation.

The contract consists of two parts. The first part determines whether or not the contract carries monitoring rights. The second part is the enforceable payment

$$f : \{x_L, x_H\} \rightarrow \mathbb{R}_+.$$

To interpret  $f$  ignore for a moment the entrepreneur’s budget constraint. The number  $f(x)$  denotes the payment that the investor obtains through enforcement, given that the cash flow realization is  $x$ . If the investor is informed, she expects to obtain  $f(x)$  from enforcement. If she is uninformed, she expects to obtain  $(1 - \beta)f(x_L) + \beta f(x_H)$

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<sup>7</sup>The analysis and the results remain essentially identical with idiosyncratic bankruptcy costs. This paper abstracts from idiosyncratic costs as they do not yield additional economic insights.

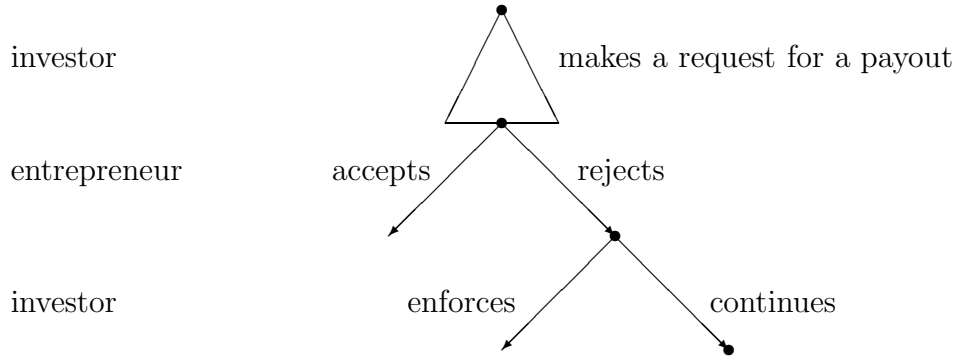


Figure 2: One Round of Renegotiation

since she does not know the cash flow realization. The *impartiality constraint*

$$f(x_L) \leq f(x_H) \quad (1)$$

ensures that the court is impartial: it seizes less from the entrepreneur when the cash flow realization is low than when it is high.

The *ex ante budget constraint* of the entrepreneur is  $x - b \geq 0$ . Limited liability of the entrepreneur ensures that the court cannot put the entrepreneur into debt. As a consequence, the *limited liability constraint*

$$f(x) \leq x - b \quad (2)$$

obtains. The *ex post budget constraint* of the entrepreneur is  $x - b - v \geq 0$ . Limited liability implies that the ex post enforceable payment is

$$F(x, v) := \min \{ f(x), x - b - v \} \quad (3)$$

The key intuition comes from (i) limited liability and (ii) the fact that the contract is signed before the entrepreneur makes his payout  $v$ . If the entrepreneur has made a small payout  $v$ , a large part of the project's cash flow is still disposable. The entrepreneur can afford the payment  $f(x)$  in addition to the payout  $v$  that he already made. In this case the court transfers the payment specified by the contract, that is,  $F(x, v) = f(x)$ . If the entrepreneur has made a very large payout  $v$ , he has not enough funds available: the only way the court can transfer  $f(x)$  is by putting the entrepreneur into debt. As this case is precluded by limited liability, the court only transfers the residual payment  $F(x, v) = x - b - v$ .

Agents' payoffs are as follows. First, suppose the investor ends the game after her monitoring decision. Then the investor's/entrepreneur's utility is

$$v \quad / \quad x - v.$$

Second, consider immediate enforcement. Immediate enforcement pertains to enforcement that occurs immediately after the investor's monitoring decision. It is distinct from enforcement during renegotiation which is always preceded by a request and a rejection. In the case of immediate enforcement the investor's/entrepreneur's utility is

$$v + F(x, v) - b \quad / \quad x - v - F(x, v) - b.$$

Third, consider renegotiation. The parameter  $\delta \in (0, 1)$  represents agents' time preferences. Agents' utilities in successive rounds are discounted by  $\delta$ . If the investor makes request  $r$  in round  $k$  and the entrepreneur accepts, the investor's/entrepreneur's utility is

$$\delta^k(v + r) \quad / \quad \delta^k(x - v - r).$$

If the entrepreneur refuses and the investor enforces, the investor's/entrepreneur's utility is

$$\delta^k(v + F(x, v) - b) \quad / \quad \delta^k(x - v - F(x, v) - b).$$

### 3 Optimal Contract and Endogenous Payout Policy

This section solves the model. The equilibrium concept is that of a perfect Bayesian equilibrium with subgame perfection. The analysis proceeds backwards.

#### 3.1 Informed Investor

Consider an informed investor in the last stage of the game. She is informed because she has monitored or because the entrepreneur has revealed his type. There is no asymmetric information: both agents know the cash flow's realization  $x$ . The investor decides whether to end the game, whether to enforce immediately, or whether to renegotiate. Renegotiation is straightforward. The investor makes a request. If the entrepreneur refuses in the first round, the investor enforces. As there is no asymmetric information, agents do not gain by delaying an agreement. To decide on her optimal strategy during renegotiation, the investor takes into account the entrepreneur's reaction to potential requests.

**Lemma 1.** *In equilibrium, the entrepreneur accepts a request if he is indifferent between accepting and subsequent enforcement.*

Figure 3 illustrates the intuition behind Lemma 1. It follows from a Bertrand-type argument. The investor knows that if she makes a very low request, the entrepreneur accepts because of the threat of enforcement. Her utility is increasing in her request as long as the entrepreneur accepts. The investor also knows that if she makes a very high request, the entrepreneur rejects since he prefers enforcement. The investor's

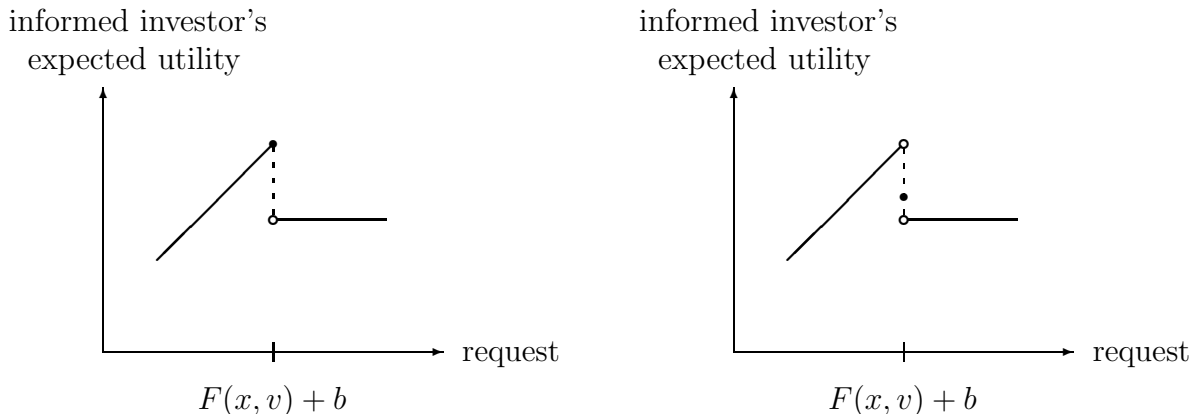


Figure 3: On the left hand side, the entrepreneur accepts the request  $F(x, v) + b$  with probability one. On the right hand side, the entrepreneur rejects the request  $F(x, v) + b$  with positive probability

utility is constant in her request as long as the entrepreneur rejects. Bankruptcy costs imply a jump downwards in the investor's utility at the threshold between acceptance and rejection. The entrepreneur is indifferent between accepting and rejecting at this threshold. His decision whether or not to accept determines the type of discontinuity of the investor's utility. The investor's optimization problem has a solution if and only if the entrepreneur accepts with probability one. By definition, the investor's optimization problem has a solution in equilibrium. As a consequence, the entrepreneur accepts in equilibrium if he is indifferent between accepting and subsequent enforcement.

**Proposition 1** (Informed Investor). *Assume that discounting is sufficiently moderate.<sup>8</sup> At the last stage of the game, the informed investor enters renegotiation, makes the request  $F(x, v) + b$  in the first round, and the entrepreneur accepts. The investor's/entrepreneur's utility is*

$$\delta(v + F(x, v) + b) \quad / \quad \delta(x - v - F(x, v) - b). \quad (4)$$

In the spirit of Proposition 1, let

$$\pi_i^E := \delta(x_E - v - F(x_E, v) - b), \quad E \in \{L, H\}$$

denote the utility of the entrepreneur when the investor is informed.

The case of the informed investor illustrates two key features of the model. First, agents have incentives to avoid bankruptcy and consequently renegotiate their way

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<sup>8</sup>This statement means that  $\delta$  exceeds a given constant in the unit interval. This constant does not contribute to the economic intuition and is not stated explicitly. It can be derived from the corresponding proofs.

around enforcement. The key driver of this result is that enforcement entails dead-weight costs. Second, the investor has the first-mover advantage. She anticipates the entrepreneur's reaction in advance and exploits it. The first-mover advantage yields a double benefit to the investor: (i) she avoids paying her own bankruptcy costs and (ii) she coaxes the entrepreneur towards transferring his bankruptcy costs to her. I refer to this effect as the *double benefit of renegotiation*.

### 3.2 Uninformed Investor at the Last Stage of the Game

Consider an uninformed investor at the last stage of the game. The entrepreneur knows the cash flow realization but the investor does not, that is,  $\beta_v \in (0, 1)$ . The investor decides whether to end the game, whether to enforce immediately, or whether to renegotiate. Renegotiation is more involved than in Section 3.1 since there is asymmetric information. In the following, refer to an entrepreneur with a low cash flow realization  $x_L$  as the *low type*. Vice versa, the *high type* has a high cash flow realization  $x_H$ . For notational convenience, let

$$F_L := F(x_L, v), \quad F_H := F(x_H, v).$$

There are two potential equilibria during renegotiation under asymmetric information. First, the investor renegotiates according to a worst case scenario in the following sense: she makes such a low request in the first round that every type accepts. This request is  $F_L + b$ . It makes the low type indifferent between accepting and enforcement. By Lemma 1, the low type accepts in equilibrium. The high type accepts since (i) he cannot hope for a lower request in any case and (ii) he strictly prefers accepting to enforcement. I refer to this case as *take-it-or-leave-it (t)*.

Second, the investor extends renegotiation to two rounds. In the first round she makes a request  $r_1$  such that the high type accepts and the low type rejects. In the second round she makes a request  $r_2$  such that the low type accepts. I refer to this case as *elicitation tactics (e)*.

The request in the second round is

$$r_2 := F_L + b,$$

the same as in the take-it-or-leave-it case. Request  $r_2$  makes the low type indifferent between accepting and enforcement. By Lemma 1, the low type accepts in equilibrium. The high type prefers accepting  $r_1$  in round 1 to (i) accepting  $r_2$  in round two (no-mimicking) and to (ii) enforcement in round two, that is,

$$\max \left\{ \delta^2(x_H - v - r_2), \delta^2(x_H - v - F_H - b) \right\} \leq \delta(x_H - v - r_1).$$

This inequality is equivalent to

$$r_1 \leq \delta \min \left\{ r_2, F_H + b \right\} + (1 - \delta)(x_H - v). \quad (5)$$

Impartiality (1) implies  $F_L \leq F_H$ . Therefore  $r_2 \leq F_H + b$  and the minimum operator in (5) is equal to  $r_2$ . The investor chooses the largest request  $r_1$  such that (5) holds, that is, she chooses

$$r_1 := \delta r_2 + (1 - \delta)(x_H - v).$$

The high type accepts by a Bertrand-type argument analogous to Lemma 1. The low type strictly prefers<sup>9</sup> accepting  $r_2$  in round two to accepting  $r_1$  in round one.

The intuition behind elicitation tactics comes from the following two properties of the request in the first round: (i) the request is high enough such that the low type rejects and (ii) it is low enough that the high type has no incentive to mimic the low type. The investor starts out with a high request in round one and decreases<sup>10</sup> her request in round two.

If the investor is fairly certain that she faces a high type, she might be tempted to consider the following strategy: she makes a request larger than  $r_1$  and forces the high type to accept by threatening enforcement. This approach cannot be an equilibrium since the threat of enforcement is not credible. The intuition is as follows. Suppose the project's cash flow realization is low. The low type cannot afford the large request and therefore rejects. The investor updates her belief. She knows that she faces a low type since the high type would have accepted. If she enforces, she has to pay bankruptcy costs. If she deviates and initiates another round of renegotiation, she profits from the double benefit of renegotiation. As a consequence, she deviates. Her threat of enforcement is not credible.

**Lemma 2.** *In equilibrium, the investor cannot make a request larger than  $r_1$  and force the high type to accept by threatening enforcement if he rejects. The threat of enforcement is not credible since the investor has an incentive to deviate.*

**Remark 1** (Bargaining Power). The informed investor forces the high type to accept the request  $F_H + b$  since her threat of enforcement is credible by Proposition 1. The largest request that the high type accepts from the uninformed investor is  $r_1$ : the threat of enforcement is not credible for any higher request by Lemma 2. In this sense, the bargaining power of the informed investor is high relative to the uninformed investor whenever the entrepreneur is of the high type. If the entrepreneur is of the low type, all requests are approximately the same since  $\delta$  is close to one. The bargaining power of the informed and uninformed investor is approximately equal. Ex ante, the investor has incentives to increase her bargaining power by becoming informed only if she is fairly certain that she faces a high type.

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<sup>9</sup>Observe that  $\delta(x_L - v - r_1) < \delta^2(x_L - v - r_2) \Leftrightarrow x_L - v - (1 - \delta)(x_H - v) - \delta(F_L + b) < \delta(x_L - v - (F_L + b)) \Leftrightarrow (1 - \delta)(x_L - v) < (1 - \delta)(x_H - v) \Leftrightarrow x_L < x_H$ , which is true by assumption.

<sup>10</sup>By (3),  $F_L \leq x_L - b - v$ . Therefore  $r_2 = F_L + b \leq x_L - v < x_H - v \Rightarrow r_2 < x_H - v \Rightarrow (1 - \delta)r_2 < (1 - \delta)(x_H - v) \Rightarrow r_2 < (1 - \delta)(x_H - v) + \delta r_2 \Rightarrow r_2 < r_1$ .

The two equilibrium properties of renegotiation from Section 3.1 also apply to this section. First, agents never enforce during renegotiation because of the deadweight costs of bankruptcy. Second, the investor exploits the double benefit of renegotiation: she avoids paying bankruptcy costs and she coaxes the entrepreneur towards transferring his bankruptcy costs to her.

The double benefit of renegotiation ensures that the investor never ends the game immediately after her monitoring decision. The additional utility from coaxing the entrepreneur towards transferring his bankruptcy costs outweighs the time costs of waiting for one additional round. The following proposition summarizes.

**Proposition 2** (Uninformed Investor Part 1). *Assume that discounting is sufficiently moderate. At the last stage of the game, the uninformed investor renegotiates through take-it-or-leave-it or elicitation tactics, or she enforces immediately. The investor never ends the game immediately after her monitoring decision. Her expected utilities from playing take-it-or-leave-it and elicitation tactics are*

$$\pi_t^I := \delta(v + F_L + b), \quad \pi_e^I := \delta^2(v + F_L + b) + \delta(1 - \delta)\beta_v x_H,$$

respectively. The entrepreneur's utilities are

$$\pi_t^E := \delta(x_E - v - F_L - b), \quad \pi_e^E := \delta^2(x_E - v - F_L - b) \quad E \in \{L, H\}.$$

### 3.3 Uninformed Investor at the Second to Last Stage

Consider the uninformed investor at the second to last stage of the game. Suppose that the contract carries monitoring rights. If the investor monitors ( $m$ ), she is subsequently informed. By Proposition 1, her expected utility is

$$\pi_m^I := \delta[v + (1 - \beta_v)F_L + \beta_v F_H + b - c].$$

The entrepreneur's utility is  $\pi_m^E := \pi_i^E$  since the investor is subsequently informed.

Monitoring strictly dominates<sup>11</sup> immediate enforcement. The intuition behind this result is that enforcement entails monitoring by the court. As a consequence, monitoring by the investor is less costly than enforcement because of the absence of additional legal fees. Proposition 2 then immediately implies the following:

**Proposition 3** (Uninformed Investor Part 2). *Assume that discounting is sufficiently moderate. Consider the investor at the second to last stage of the game. Suppose the entrepreneur has not signaled his type. That is, suppose that  $\beta_v \in (0, 1)$ . Then the investor plays either take-it-or-leave-it, elicitation tactics, or she monitors.*

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<sup>11</sup>Immediate enforcement yields the expected utility  $\delta(v + (1 - \beta_v)F_L + \beta_v F_H - b) = \delta(v + (1 - \beta_v)F_L + \beta_v F_H + b - 2b) < \delta(v + (1 - \beta_v)F_L + \beta_v F_H + b - c) = \pi_m^I$  since  $c < 2b$  by Section 2.

Proposition 3 implies that the uninformed investor always enters renegotiation. The investor always makes use of her opportunity to renegotiate for three reasons. First, if she plays take-it-or-leave-it, she avoids enforcement and profits from the double benefit of renegotiation. Second, even if she does not monitor, she still can extract information through elicitation tactics. Third, if she monitors, she obtains additional information and uses this information to extract more surplus from the investment project.

### 3.4 Payout Policy Induces a Low Enforceable Payment for the High Type

The following four steps derive the optimal contract and the entrepreneur's payout policy. The key intuition is as follows. The investor's posterior belief  $\beta_v \in [0, 1]$  determines whether or not she is informed. If she is uninformed, her posterior determines whether she plays take-it-or-leave-it, elicitation tactics, or whether or not she monitors. As a consequence, the investor's posterior determines whether the entrepreneur obtains  $\pi_i^E$ ,  $\pi_t^E$ ,  $\pi_e^E$ , or  $\pi_m^E$ . The entrepreneur's payout policy determines the investor's posterior. As a consequence, the entrepreneur's payout policy determines whether the entrepreneur obtains  $\pi_i^E$ ,  $\pi_t^E$ ,  $\pi_e^E$ , or  $\pi_m^E$ . That is, the entrepreneur decides through his payout policy whether he gets  $\pi_i^E$ ,  $\pi_t^E$ ,  $\pi_e^E$ , or  $\pi_m^E$  by taking into account the updating of the investor's belief.

On-equilibrium beliefs are consistent with Bayes' rule and equilibrium strategies. The low type's strategy is optimal given the high type's strategy and vice versa. In this sense, the investor's on-equilibrium posterior beliefs are a consequence of the low and the high type's payout policies satisfying this fixed-point requirement. Off-equilibrium beliefs are unconstrained.

In the following four steps, think of  $\pi_i^E$ ,  $\pi_t^E$ ,  $\pi_e^E$ , and  $\pi_m^E$  as functions of the voluntary payout  $v$ . Also suppose for the time being that the contract carries monitoring rights.

#### Step 1: The Low Type's Limited Liability Constraint Is Binding

The following proposition summarizes the key result of Step 1.

**Proposition 4** (Limited Liability). *Assume that discounting is sufficiently moderate. Then the low type's limited liability constraint (2) is binding in equilibrium. That is,  $f(x_L) = x_L - b$ .*

Consider the economic intuition behind this result. Suppose the low type's limited liability constraint is not binding, that is,  $f(x_L) < x_L - b$ . The entrepreneur knows by Sections 3.1 and 3.3 that the investor always enters renegotiation and that this result holds for *all* posterior beliefs  $\beta_v \in [0, 1]$ . The enforceable payment  $f(x_L)$  of the low type plays a key role during renegotiation. Although agents end up renegotiating their way around enforcement,  $f(x_L)$  determines the entrepreneur's utility since the

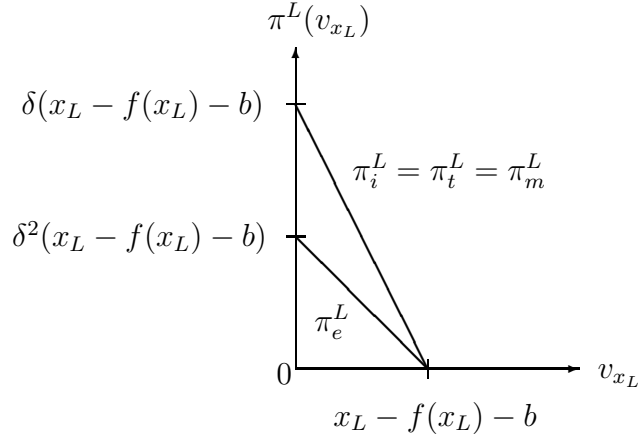


Figure 4: Low Type's Utility When  $f(x_L) < x_L - b$

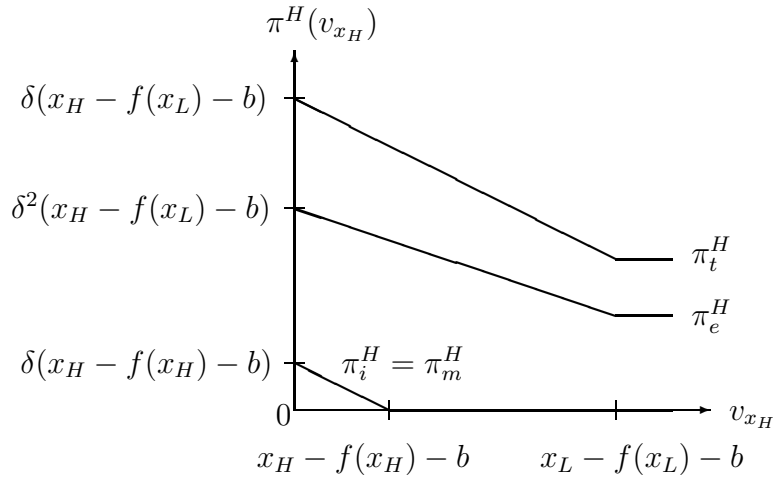


Figure 5: High Type's Utility When  $f(x) < x - b$ ,  $x \in \{x_L, x_H\}$

threat of enforcement matters in equilibrium. By refusing a payout, the entrepreneur takes advantage of the non-binding limited liability constraint. With a zero payout the investor cannot take away the whole cash flow from him even if the investor enforces. The entrepreneur knows that the investor uses any positive payout to lock in a profit. He also knows that irrespective of his payout, the investor extracts as much surplus as possible at the end of the game: the investor cannot credibly commit to abstaining from renegotiation in return for receiving a strictly positive payout. As a consequence, the entrepreneur refuses to make a payout. Figures 4 and 5 illustrate the intuition behind the entrepreneur's incentives: the entrepreneur's utilities  $\pi_i^E$ ,  $\pi_t^E$ ,  $\pi_e^E$ , and  $\pi_m^E$  all have their maximum at a payout of zero.

The investor retraces the entrepreneur's reasoning. She knows that whenever the low type's limited liability constraint is non-binding, the entrepreneur pools his payout

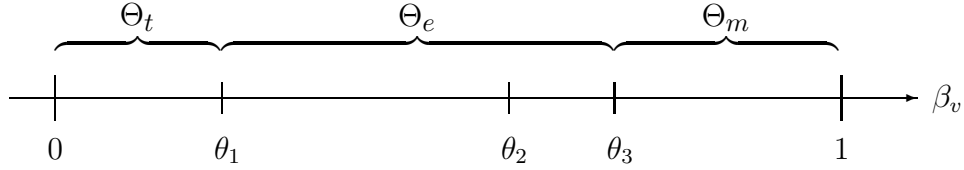


Figure 6: The Intervals  $\Theta_t$ ,  $\Theta_e$ , and  $\Theta_m$  Partition the Unit Interval

at zero. The number  $f(x_L)$  enters the investor's expected utilities  $\pi_t^I$ ,  $\pi_e^I$ , and  $\pi_m^I$  with a positive slope since (3) and payout pooling at zero imply  $F_L = f(x_L)$ . As a consequence, there cannot be an equilibrium with  $f(x_L) < x_L - b$  since the investor always has an incentive to deviate by increasing  $f(x_L)$ .

The same type of argument does not go through in analogy for the enforceable payment  $f(x_H)$  of the high type. The entrepreneur does not signal in the derivation of Proposition 4. In contrast, there are cases in which the entrepreneur has incentives to signal when the limited liability constraint of the low type is binding. Signaling prevents the argument above from going through in analogy for  $f(x_H)$ .

## Step 2: Posterior Beliefs and the Investor's Best Reply

By Proposition 4, consider  $f(x_L) = x_L - b$  in the remainder of this paper. For all  $f(x_H) > f(x_L)$  partition<sup>12</sup> the unit interval into

$$\begin{aligned}\Theta_t &:= (0, \min\{\theta_1, \theta_2\}] \cap (0, 1) \\ \Theta_e &:= [\theta_1, \theta_3] \cap (0, 1) \\ \Theta_m &:= [\max\{\theta_2, \theta_3\}, 1) \cap (0, 1)\end{aligned}$$

with

$$\theta_1 := \frac{x_L}{x_H}, \quad \theta_2 := \frac{c}{f(x_H) - f(x_L)}, \quad \theta_3 := \frac{c - (1 - \delta)x_L}{f(x_H) - f(x_L) - (1 - \delta)x_H}.$$

This partition is straightforward, as the following lemma shows. Depending on the game's parameters, the partition consists of two or three intervals. See Figure 6 for an illustration of the case with three intervals.

**Lemma 3** (Structure of  $\Theta_j$ 's). *Assume that discounting is sufficiently moderate. Suppose that  $f(x_L) = x_L - b < f(x_H)$ . Then either*

$$\Theta_t = (0, \theta_2] \cap (0, 1), \quad \Theta_e = \emptyset, \quad \Theta_m = [\theta_2, 1) \cap (0, 1)$$

or

$$\Theta_t = (0, \theta_1] \cap (0, 1), \quad \Theta_e = [\theta_1, \theta_3] \cap (0, 1), \quad \Theta_m = [\theta_3, 1) \cap (0, 1), \quad \theta_1 \leq \theta_3.$$

<sup>12</sup>The standard notation  $[a, d] = [a, d) = (a, d] = \emptyset$  for all  $d < a$  applies.

If  $\beta_v \in \Theta_t$ , the posterior is relatively close to zero. The investor is fairly certain that she faces a low type. In this sense, she is relatively pessimistic about the project's cash flow realization. If  $\beta_v \in \Theta_e$ , the investor is more optimistic about the cash flow realization compared to the case  $\beta_v \in \Theta_t$ . If  $\beta_v \in \Theta_m$ , the posterior is relatively close to one. The investor is fairly certain that she faces a high type. In this sense, she is relatively optimistic about the project's cash flow realization.

**Proposition 5** (Posterior Beliefs Matter). *Assume that discounting is sufficiently moderate. Consider the investor at the second to last stage of the game. If  $f(x_L) = f(x_H)$ , the uninformed investor never plays  $m$ . The uninformed investor decides between playing  $t$  and  $e$  by*

$$\pi_t^I \leq \pi_e^I \iff \beta_v \in [\theta_1, 1) \cap (0, 1).$$

*If  $f(x_L) < f(x_H)$  and  $\beta_v \in \Theta_j$ , then it is optimal for the investor to play  $j$ .*

Similar to Rubinstein (1985), Proposition 5 specifies a clear connection between the investor's belief and the equilibrium. The economic intuition is as follows. Consider the investor immediately after she has received the entrepreneur's payout  $v$ . Suppose the investor is uninformed, that is,  $\beta_v \in (0, 1)$ . If the investor is fairly certain that she faces a low type ( $\beta_v$  is close to zero, that is,  $\beta_v \in \Theta_t$ ), she plays take-it-or-leave-it. Elicitation tactics are not optimal. Since the investor believes to be facing a low type, she expects the entrepreneur to reject her first request and to accept her second request in case she plays  $e$ . The second request is the same request that the investor would make in the first round if she would play  $t$ . That is, by playing  $t$ , the investor expects the entrepreneur to accept the same request one round earlier. Time is valuable. As a consequence, the investor prefers playing take-it-or-leave-it over elicitation tactics. Monitoring is also not optimal. The investor is pessimistic about the project. She believes that with high likelihood she will find her suspicion about the project's state confirmed if she monitors. The request that she makes when she knows that the project is in the bad state is identical to her take-it-or-leave-it request. In both cases the entrepreneur accepts. In this sense, the investor knows that with all likelihood the game ends with the entrepreneur accepting identical requests. She also knows that she has to pay monitoring costs in case she plays  $m$  while she avoids paying monitoring costs in case she plays  $t$ . As a consequence, she prefers playing take-it-or-leave-it over monitoring.

Suppose the investor's optimism increases in the sense that  $\beta_v \in \Theta_e$ . Playing elicitation tactics is optimal for the investor. The tradeoff described in the previous paragraph goes into the opposite direction. The investor is relatively certain that she faces a high type. She knows that the high type accepts the request in the first round when she plays elicitation tactics. This request is larger than the request that she would make if she would play take-it-or-leave-it. As a consequence, she prefers playing elicitation tactics over playing take-it-or-leave-it. Monitoring is still not optimal: monitoring costs are large relative to the expected utility from playing elicitation tactics.

If the investor is fairly certain that she faces a high type ( $\beta_v$  is close to one, that is,  $\beta_v \in \Theta_m$ ), she monitors. This result is due to the following key difference between playing  $t$  or  $e$  and playing  $m$ : the investor plays a game of incomplete information<sup>13</sup> in the case of  $t$  and  $e$ , while she plays a perfect information (sub)game after monitoring. Whenever she faces a high type, her bargaining power<sup>14</sup> under perfect information is large compared to incomplete information. The increase in bargaining power more than compensates for the decrease in expected utility caused by monitoring costs. As a consequence, the investor monitors if she is fairly certain that she faces a high type.

### Step 3: Prior Beliefs and the Entrepreneur’s Best Reply

By Proposition 5 the entrepreneur knows the investor’s response to a given posterior belief. In this step the entrepreneur decides on his optimal payout policy by taking into account the effect of payout policy on posterior beliefs. In this sense, this step considers the entrepreneur’s best reply against a given contract.

**Proposition 6** (Prior Beliefs Matter). *Assume that discounting is sufficiently moderate. Suppose that  $f(x_H) = f(x_L)$ . If  $\beta < \theta_1$ , the entrepreneur pools his payout at zero. If  $\beta \geq \theta_1$ , the entrepreneur signals his type.*

*Suppose that  $f(x_H) > f(x_L)$ . If<sup>15</sup>  $\beta \in (\Theta_t \cup \Theta_e)^o$ , the entrepreneur pools his payout at zero. If  $\beta \in \Theta_m$ , the entrepreneur plays a (potentially degenerate) mixed strategy between signaling and payout pooling at zero.*

Proposition 6 is about the entrepreneur revealing information to the investor. Focusing on the high type is sufficient for the following reason. The low type’s budget constraint is binding by Proposition 4. As a consequence, the low type’s utility is always zero, independent of her payout and independent of the investor’s subsequent choice of action. Any payout strategy of the low type is optimal for any given payout strategy of the high type. In this sense, the high type’s incentives determine the entrepreneur’s payout policy.

Focusing on the high type, the investor’s prior falls into two categories: either the prior is approximately correct in the sense that it is relatively close to one, or it is incorrect in the sense that the prior is relatively close to zero. Suppose the investor’s belief is incorrect. The high type has the following choices. Either he does not reveal new information by pooling his payout, or he signals his type, or he plays a mixed strategy. If he does not reveal new information, the investor continues to be incorrect in his belief. If the investor is incorrect, she plays a strategy that is targeted at the low

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<sup>13</sup>Strictly speaking, she faces a complete information game with imperfect information. This game results from the Harsanyi transformation (see Ritzberger (2002), page 132).

<sup>14</sup>Remark 1 makes a similar argument using different reasoning.

<sup>15</sup>Using standard notation, superscript  $o$  denotes the *interior* of a set. That is, for any set  $A$ , the set  $A^o$  is the largest open set contained in  $A$ .

type instead of the high type. If instead the high type reveals information by signaling, the investor is subsequently informed and targets the high type. The high type prefers to play against an investor who is misled in the sense that she targets the wrong type. As a consequence, he pools his payout.

Suppose the investor's prior is approximately correct. If  $f(x_H) = f(x_L)$  and the high type pools, the investor's posterior is equal to her prior. She plays elicitation tactics since she expects that the high type accepts the high request in the first round. If the high type signals, the investor is subsequently informed. The enforceable payment  $f(x_H)$  of the high type is as low as it can be since the impartiality constraint (1) is binding. As a consequence, the request that the informed investor makes is lower than the request made by the uninformed investor playing  $e$ . The high type prefers the lower request. As a consequence, he signals his type.

If the investor's prior is approximately correct and if  $f(x_H) > f(x_L)$ , then the high type is indifferent between signaling and payout pooling for the following reason. Suppose the high type pools his payout. The investor's posterior is equal to her prior and she is relatively certain that she faces a high type. She monitors because of the reasons detailed in Step 2. Both monitoring by the investor and signaling by the entrepreneur make the investor informed. That is, both payout pooling (which leads to monitoring) and signaling imply the same outcome for the high type. As a consequence, the high type is indifferent between payout pooling and signaling.

**Remark 2.** If  $f(x_H) = f(x_L)$  and  $\beta < \theta_1$ , it is also optimal for the entrepreneur to signal. The high type's enforceable payment  $f(x_H)$  is as low as it can be since the impartiality constraint (1) is binding. As a consequence, signaling yields the same utility to the high type as payout pooling. With  $f(x_H) = f(x_L)$ , the investor's expected utility remains unchanged when the entrepreneur signals instead of pooling his payout.

#### Step 4: Optimal Contract and Payout Policy

Consider a given contract  $f(x_H) > f(x_L)$  and suppose that  $\beta \in \Theta_m$ . The entrepreneur is indifferent between signaling and payout pooling by Proposition 6. He plays a mixed strategy. With probability  $\zeta \in [0, 1]$  he signals his type and with probability  $1 - \zeta$  he pools his payout. Contrary to the entrepreneur, the investor cares about the mixing probability: with probability  $\zeta$ , she is informed and does not have to pay monitoring costs while with probability  $1 - \zeta$  she pays monitoring costs. That is, the investor prefers a large value of  $\zeta$  while the entrepreneur is indifferent.

The entrepreneur would like the investor to choose a small enforceable payment. To achieve this objective, he takes advantage of the investor's preference for signaling. The entrepreneur offers a trade-off to the investor. He rewards the investor for choosing a small enforceable payment by revealing information, that is, by signaling. Similarly, he punishes the investor for choosing a large enforceable payment by concealing information, that is, by pooling his payout.

This trade-off only works if the entrepreneur is indifferent between payout pooling and signaling. The entrepreneur is only indifferent when payout pooling entails monitoring by the investor. Monitoring after payout pooling is by Step 2 only optimal if the investor is relatively certain that she faces a high type. As a consequence, the entrepreneur's trade-off only works if the prior  $\beta$  is relatively large. In this case, the following equilibrium ensues. The entrepreneur reveals information by signaling. In return, the investor chooses an enforceable payment for the high type such that his limited liability constraint is not binding. That is, signaling gives the investor incentives to choose a relatively small enforceable payment  $f(x_H)$  for the high type.

Although the enforceable payment  $f(x_H)$  of the high type is small relative to its maximum implied by limited liability (2), it is large relative to the enforceable payment  $f(x_L)$  of the low type. The entrepreneur has to be indifferent between payout pooling and signaling for the trade-off to work. The entrepreneur is only indifferent if the investor monitors after payout pooling. The investor only monitors if the expected increase in utility from becoming informed is large relative to the monitoring costs that she has to pay. The expected increase in utility is only large if the enforceable payment for the high type is large. As a consequence, the investor chooses a relatively large enforceable payment whenever she is relatively certain that she faces a high type. Only then does the entrepreneur have incentives to signal his type.

The investor does not monitor in equilibrium although she assigns monitoring rights to the contract. To verify this statement, suppose the contract does not carry monitoring rights. The entrepreneur knows that if he pools, the investor subsequently plays take-it-or-leave-it or elicitation tactics. In particular, the investor does not monitor. The entrepreneur also knows that his utility from signaling is smaller than the utility that he obtains if the investor plays take-it-or-leave-it or elicitation tactics. As a consequence, he pools his payout to conceal information from the investor. The investor knows that the entrepreneur conceals information whenever she does not assign monitoring rights to the contract. She also knows that the entrepreneur reveals information if the contract carries monitoring rights since her threat of monitoring is credible. As a consequence, it cannot be optimal for the investor not to assign monitoring rights. In order to be informed ex post and to increase her bargaining power, she assigns monitoring rights whenever she is relatively certain to face a high type.

Suppose the investor is relatively certain to face a low type. Monitoring costs are large relative to the expected increase in utility that results from becoming informed. The investor never monitors and instead plays take-it-or-leave-it or elicitation tactics. That is, independent of the entrepreneur's payout strategy, the investor cannot credibly commit to monitoring. As a consequence, the entrepreneur conceals information by pooling his payout: he knows that the investor is not willing to incur the cost of finding out his true type. In this sense, the investor knows ex ante that she will continue to be uninformed ex post. Only the enforceable payment for the low type matters if the investor is uninformed: as Lemma 2 explains, the uninformed investor cannot commit

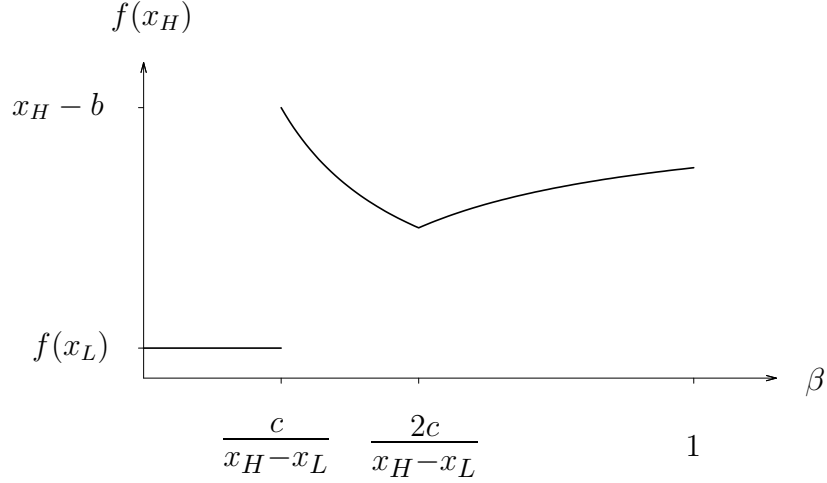


Figure 7: Optimal Enforceable Payment for the High Type when  $\delta \rightarrow 1$

to making a very large request that is a function of  $f(x_H)$ . As a consequence, it is optimal for the investor to choose an enforceable payment  $f(x_H)$  for the high type that is close to the enforceable payment  $f(x_L)$  for the low type. The optimal contract does not carry monitoring rights: ex ante the investor knows that she would not make use of the monitoring opportunity ex post, even if the contract would carry monitoring rights.

The following proposition formalizes the intuitive argument above. It considers two different cases,  $\beta < \theta_1$  and  $\theta_1 \leq \beta$ . The difference results from comparing monitoring with playing take-it-or-leave-it in case  $\beta < \theta_1$  and from comparing monitoring with elicitation tactics in case  $\theta_1 \leq \beta$ . Both cases are similar in the sense that the former is the limit of the latter when discounting vanishes, that is, when  $\delta \rightarrow 1$ . Figure 7 illustrates the enforceable payment of the high type as a function of the prior belief in the limiting case.

**Theorem** (Optimal Contract and Payout Policy). *Assume that discounting is sufficiently moderate. Define*

$$\underline{\beta} := \frac{c}{x_H - x_L}, \quad \bar{\beta} := \frac{2c}{x_H - x_L},$$

$$\underline{\beta}' := \frac{c - (1 - \delta)x_L}{x_H - x_L - (1 - \delta)x_H}, \quad \bar{\beta}' := \frac{2c - (1 - \delta)x_L}{x_H - x_L - (1 - \delta)x_H}.$$

By Proposition 4,  $f(x_L) = x_L - b$ . Suppose that  $\beta < \theta_1$ . Then:

$$f(x_H) = \begin{cases} f(x_L) & , \beta \in (0, \underline{\beta}) \\ f(x_L) + c/\beta & , \beta \in [\underline{\beta}, \bar{\beta}] \\ x_H - b - c/\beta & , \beta \in (\bar{\beta}, 1) \end{cases}$$

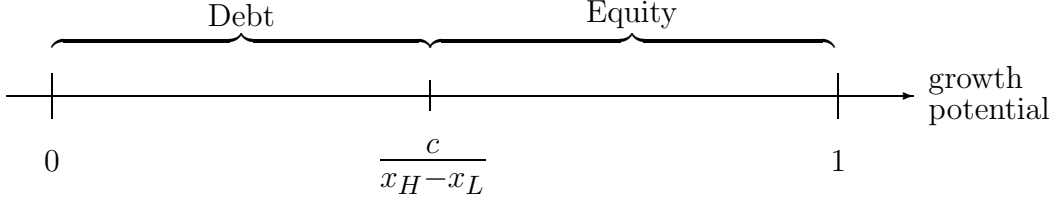


Figure 8: Debt and Equity

*Payout policy and monitoring rights relate as follows: If  $\beta < \underline{\beta}$ , the contract does not carry monitoring rights and the entrepreneur pools his payout. Vice versa, if  $\underline{\beta} \leq \beta$ , the contract carries monitoring rights and the entrepreneur signals his type.*

*Suppose that  $\theta_1 \leq \beta$ . Then:*

$$f(x_H) = \begin{cases} f(x_L) + 2(1 - \delta)(x_H - x_L) & , \beta \in (0, \underline{\beta}) \\ f(x_L) + c/\beta + (1 - \delta)(x_H - x_L/\beta) & , \beta \in [\underline{\beta}, \bar{\beta}] \\ x_H - b - c/\beta & , \beta \in (\bar{\beta}, 1) \end{cases}$$

*Payout policy and monitoring rights relate in the same way as in the case  $\beta < \theta_1$  with  $\underline{\beta}$  replaced by  $\underline{\beta}'$ .*

**Remark 3.** Signaling pertains to the low type making a different payout than the high type. The payout of the low type can be chosen arbitrarily close to the high type's payout in equilibrium. This result demonstrates that the primary function of payout policy is the mitigation of information asymmetry, not the transfer of funds.

## 4 Debt, Equity, and Payout Policy

The main theorem's second part collapses to the first part when discounting vanishes, that is, when  $\delta \rightarrow 1$ . Since discounting is assumed to be sufficiently small throughout the paper, the following corollary restates the main theorem for the limiting case.

**Corollary.** *As discounting vanishes, that is, as  $\delta \rightarrow 1$ , the following result obtains. If  $\beta < c/(x_H - x_L)$ , the optimal contract is state-independent since  $f(x_L) = f(x_H)$ , and the contract does not carry monitoring rights outside of bankruptcy. The entrepreneur conceals information by pooling his payout at zero. If  $c/(x_H - x_L) \leq \beta$ , the optimal contract is state-contingent since  $f(x_H) \geq f(x_L) + c/\beta$ , and the contract carries monitoring rights. The entrepreneur reveals the state of the project's cash flow by signaling. Whenever  $c/(x_H - x_L) \neq \beta$ , the limited liability constraint of the high type is not binding.*

Figure 8 illustrates how the optimal contract relates to debt and equity. Two cases obtain. First, suppose that  $\beta < c/(x_H - x_L)$ . That is, monitoring costs are large, the

stakes are small, and agents are relatively certain that the investment project's growth potential is small. The stakes are small in the sense that potential realizations of the cash flow are relatively close together. Then outside of bankruptcy the contract does not carry monitoring rights and induced cash flow rights are state-independent. Payout policy in terms of dividends is nonexistent in the sense that the entrepreneur makes no payout and does not reveal information to the investor. As a consequence, the optimal contract is debt-like.

Second, suppose that  $c/(x_H - x_L) \leq \beta$ . That is, monitoring costs are small, the stakes are large, and agents are relatively certain that the growth potential of the project is high. Then the contract carries unconditional monitoring rights and induced cash flow rights are state-contingent. The entrepreneur uses payout policy to reveal information. That is, endogenous dividend signaling obtains. As a consequence, the optimal contract is equity-like.

Payout policy in the case of equity is important in the following sense. By revealing information, the entrepreneur reduces the investor's uncertainty. That is, the investor knows ex ante that she is going to be informed ex post. Reduced uncertainty comes at a price: the entrepreneur signals only if the investor reduces the enforceable payment for the high type relative to the limited liability constraint (see Figure 7). In this sense, payout policy plays a key role in reducing the ex ante uncertainty implied by the optimal choice of contract.

Figure 8 illustrates the key empirical prediction pertaining to capital structure choice. If a firm has a large growth potential, if its cash flows are risky, and if a credible information policy is cost-efficient to implement, then its leverage is low. The same holds vice versa for high leverage. Credible information policy may pertain to good corporate governance or to firm size.

A second empirical prediction relates to bankruptcy: since bankruptcy entails dead-weight costs, agents renegotiate their way around bankruptcy. This finding rationalizes the large number of bankruptcies under Chapter 11 relative to Chapter 7. It shows that Chapter 11 improves ex post efficiency.

## 5 Conclusion

This paper rationalizes the diversity of outside claims. It shows why equity-holders have state-contingent cash flow rights and unconditional monitoring rights, why debt-holders have state-independent cash flow rights outside of bankruptcy and monitoring rights only in case of bankruptcy, and why dividend signaling pertains to equity only. This paper predicts that leverage is low when companies have a large growth potential, when cash flows are relatively risky, and when a credible information policy to outside investors is cost-efficient to implement (e.g. good corporate governance or small firm size). The same holds vice versa for high leverage.

## Appendix

*Proof of Lemma 1.* This proof is based on a Bertrand-type argument. Consider the request  $r = F(x, v) + b$  that makes the entrepreneur indifferent between accepting and subsequent enforcement. The investor's payoff function is strictly increasing in her request on the interval  $[0, r)$  since the entrepreneur always accepts. At the request  $r - \varepsilon$  the investor's payoff is  $\delta(v + F(x, v) + b - \varepsilon)$ , for  $\varepsilon > 0$ .

Assume that the entrepreneur rejects  $r$  in equilibrium with a strictly positive probability. Then the investor's payoff function exhibits a jump downwards at  $r$ : with strictly positive probability, the entrepreneur refuses the request  $r$  and consequently the investor enforces, yielding the payoff  $\delta(v + F(x, v) - b)$ . The investor faces an optimization problem with an increasing objective function on the right-open interval  $[0, r)$ . This optimization problem does not have a solution. As a consequence, it cannot be an equilibrium that the entrepreneur rejects  $r$ .  $\square$

*Proof of Proposition 1.* Entering renegotiation and making the request  $F(x, v) + b$  makes the entrepreneur indifferent. By Lemma 1, he accepts. The investor's payoff from ending the game, from immediate enforcement, and from renegotiation is

$$v, \quad v + F(x, v) - b, \quad \delta(v + F(x, v) + b),$$

respectively. If  $\delta$  is sufficiently close to one, the largest payoff obtains from entering renegotiation.  $\square$

*Proof of Lemma 2.* Assume the investor enforces in equilibrium after a request that is larger than  $r_1$ . In equilibrium, the high type accepts any request that is smaller or equal to  $F_H + b$  by a Bertrand-type argument analogous to Lemma 1. As a consequence, the investor requests  $F_H + b$  and the high type accepts. The low type rejects as he strictly prefers enforcement:  $\delta(x_L - v - F_H - b) \leq \delta(x_L - v - r_1) < \delta(x_L - v - r_2) = \delta(x_L - v - F_L - b)$  since  $r_2 < r_1$ .

Suppose nature draws a low cash flow realization. The entrepreneur is of low type and rejects. Observing the rejection, the investor updates her belief and becomes informed: she knows she faces a low type since the high type would have accepted. Enforcement yields the payoff  $\delta(v + F_L - b)$ . Initiating another round with the request  $F_L + b$  yields the payoff  $\delta^2(v + F_L + b)$  by Lemma 1. If  $\delta$  is sufficiently large, the investor has an incentive to deviate by initiating a second round. She cannot credibly commit to enforcement in the first round.

Note that in this argument is based on the case  $r_1 \leq F_H + b$ . In case  $F_H + b < r_1$  the investor strictly prefers playing  $e$ . The above strategy (request  $F_H + b$  and enforce if the entrepreneur rejects) would be suboptimal even if the investor could commit to enforcement in the first round.  $\square$

*Proof of Proposition 2.* The investor's utility from playing  $t$  is  $\pi_t^I = \delta(v + F_L + b)$  as she makes the request  $F_L + b$  and the entrepreneur accepts. Her utility from playing  $e$  is

$$\begin{aligned}
\pi_e^I &= \beta_v \delta(v + r_1) + (1 - \beta_v) \delta^2(v + r_2) \\
&= \beta_v \delta(v + (1 - \delta)(x_H - v) + \delta r_2) + (1 - \beta_v) \delta^2(v + r_2) \\
&= \beta_v \delta(v + (1 - \delta)(x_H - v)) + \delta^2((1 - \beta_v)v + r_2) \\
&= \delta(1 - \delta) \beta_v x_H + \beta_v \delta(v - (1 - \delta)v) + \delta^2((1 - \beta_v)v + r_2) \\
&= \delta(1 - \delta) \beta_v x_H + \beta_v \delta^2 v + \delta^2((1 - \beta_v)v + r_2) \\
&= \delta(1 - \delta) \beta_v x_H + \delta^2(v + r_2).
\end{aligned}$$

Ending the game yields the payoff  $v$ , which is strictly dominated by  $t$  if  $\delta$  is sufficiently close to one.

The entrepreneur's utility  $\pi_t^E$  obtains immediately from the investor's request  $F_L + b$  and the subsequent acceptance by the entrepreneur. In case of  $e$ , the low type obtains  $\pi_e^L = \delta^2(x_L - v - F(x_L, v) - b)$  and the high type obtains

$$\begin{aligned}
\pi_e^H &= \delta(x_H - v - r_1) = \delta(x_H - v - (1 - \delta)(x_H - v) - \delta(F(x_L, v) + b)) \\
&= \delta(\delta(x_H - v) - \delta(F(x_L, v) + b)) = \delta^2(x_H - v - F(x_L, v) - b).
\end{aligned}$$

As a consequence, the entrepreneur obtains  $\pi_e^E = \delta^2(x_E - v - F_L - b)$  in case the investor plays  $e$ .  $\square$

*Proof of Proposition 4.* Start by considering the case  $f(x_E) < x_E - b$  for all  $E \in \{L, H\}$ . In this case,  $\pi_i^E$ ,  $\pi_t^E$ ,  $\pi_e^E$ , and  $\pi_m^E$  all have their unique maximum at  $v_{x_E} = 0$  (see Figures 4 and 5). Throughout this proof it is important to keep in mind that the low type's strategy has to be optimal given the high type's strategy and vice versa. The investor's posterior  $\beta_v$  is a consequence of the low and the high type's payout policies satisfying this fixed-point requirement.

Suppose that in equilibrium the entrepreneur signals, that is, suppose that  $v_{x_L} \neq v_{x_H}$  is optimal. If  $v_{x_L} < v_{x_H}$ , the high type has an incentive to deviate by paying out a sufficiently small amount  $\varepsilon > 0$  such that  $v_{x_L} \neq \varepsilon < v_{x_H}$ . By making this payout he still signals but increases his utility since in an environment of zero,  $\pi_i^H$  is strictly decreasing. The same argument applies vice versa to the case  $v_{x_H} < v_{x_L}$ . As a consequence, it cannot be an equilibrium that the entrepreneur signals. The same type of argument applies to the case in which the entrepreneur plays a mixed strategy that involves signaling with a positive probability. As a consequence, the entrepreneur signals with zero probability. In other words, the entrepreneur plays a strategy such that he does not reveal his type with certainty, that is,  $\beta_v \in (0, 1)$  for all<sup>16</sup>  $v \in \text{supp}(V)$ .

<sup>16</sup>The *support* of a random variable  $V$  is defined as follows. Consider  $P(V \in B) := P(V^{-1}(B))$  for all (real) Borel sets  $B$ , where  $V^{-1}(B) := \{\omega \in \Omega \mid V(\omega) \in B\}$ . There exists a largest open Borel set  $\mathcal{O} \subseteq \mathbb{R}$  such that  $P(V \in \mathcal{O}) = 0$ . The support of the random variable  $V$  is then defined as  $\text{supp}(V) := \mathcal{O}^c$ , where superscript  $c$  denotes the complement of a set.

Suppose that  $\text{supp}(V) \cap (0, \infty) \neq \emptyset$ . That is, with positive probability the entrepreneur makes a payout larger than zero. Since  $\beta_v \in (0, 1)$  for all  $v \in \text{supp} V$ , it holds that  $\text{supp}(V|X = x_E) = \text{supp}(V)$  for all  $E \in \{L, H\}$ , although the probability distributions of the strategies of the low and the high type (induced by the random variables  $V|X = x_L$  and  $V|X = x_H$ ) may differ. Since  $\pi_t^L$ ,  $\pi_e^L$ , and  $\pi_m^L$  are all strictly increasing in  $v$  in a neighborhood of zero, and since the entrepreneur has to be indifferent between the payouts that he randomizes over, it has to hold that  $\text{supp}(V|X = x_L) = \{0, v\}$ , where  $v$  satisfies  $\pi_e^L(0) = \pi_t^L(v) = \pi_m^L(v)$  (see Figure 4). That is,  $v = (1 - \delta)(x_L - f(x_L) - b)$ . It also has to hold that whenever the investor updates to  $\beta_0$  she subsequently plays  $e$  and when she updates to  $\beta_v$  she plays  $t$  or  $m$ . Suppose the investor plays  $t$  after updating to  $\beta_v$ . Then it has to hold for the high type that  $\pi_e^H(0) = \pi_t^H(v)$  since otherwise he would not randomize and a contradiction to  $\text{supp}(V|X = x_H) \cap (0, \infty) = \text{supp}(V) \cap (0, \infty) \neq \emptyset$  would obtain.  $\pi_e^H(0) = \pi_t^H(v)$  implies  $v = (1 - \delta)(x_H - f(x_L) - b)$ . This is a contradiction to the earlier result that  $v = (1 - \delta)(x_L - f(x_L) - b)$  since by assumption  $x_L < x_H$ . As a consequence, it cannot be that the investor plays  $t$  after updating to  $\beta_v$ . It has to hold that the investor plays  $m$  after updating to  $\beta_v$  if an equilibrium exists with  $\text{supp}(V) \cap (0, \infty) \neq \emptyset$ .

Suppose the investor plays  $m$  after updating to  $\beta_v$ . Then it has to hold for the high type that  $\pi_e^H(0) = \pi_m^H(v) = \delta^2(x_H - f(x_L) - b)$ . By assumption,  $f(x_L) < x_L - b$ , so for a sufficiently large  $\delta \in (0, 1)$  it also holds that  $\delta f(x_L) + (1 - \delta)(x_H - b) < x_L - b$ . This statement implies  $\delta(x_H - x_L) < \delta^2(x_H - f(x_L) - b)$ . With  $f(x_E) = x_E - b$  it holds that  $\max\{\pi_i^H, \pi_t^H, \pi_e^H, \pi_m^H\} \leq \delta(x_H - x_L)$  for all potential payouts of the high type. By continuity and since  $\delta(x_H - x_L) < \delta^2(x_H - f(x_L) - b)$  holds with *strict* inequality, the investor can always find values  $f(x_E) < x_E - b$  that are sufficiently large such that  $\max\{\pi_t^H, \pi_e^H, \pi_m^H\} < \delta^2(x_H - f(x_L) - b)$  for all potential payouts of the high type. That is, she can always increase the utility she obtains in case nature draws a high cash flow realization. This statement holds for all posterior beliefs. Likewise, the investor can also obtain a larger utility from the low type since  $\pi_j^L \rightarrow 0$  as  $f(x_L) \rightarrow x_L - b$  for all  $j \in \{t, e, m\}$ . This statement also holds for all posterior beliefs. As a consequence, the investor has an incentive to deviate and it cannot hold that the investor plays  $m$  after updating to  $\beta_v$ .

The previous paragraphs have shown by proof of contradiction that  $\text{supp}(V) \cap (0, \infty) \neq \emptyset$  cannot hold. As a consequence,  $\text{supp}(V) \cap (0, \infty) = \emptyset$ . That is, if an equilibrium exists with  $f(x_E) < x_E - b$ , then it has to involve the entrepreneur pooling his payout at zero.

If the entrepreneur pools his payout at zero, then by (3) it holds that  $F_E = f(x_E)$  since by assumption  $f(x_E) < x_E - b$ . As a consequence,  $f(x_L)$  always enters the investor's expected utility  $\pi^I \in \{\pi_t^I, \pi_e^I, \pi_m^I\}$  with a positive slope. This statement holds for all posterior beliefs. For every function  $f$  such that  $f(x_E) < x_E - b$ , the investor can increase her expected utility by increasing  $f(x_L)$ . As a consequence, it cannot be an equilibrium that  $f(x_E) < x_E - b$  for all  $E \in \{L, H\}$ .

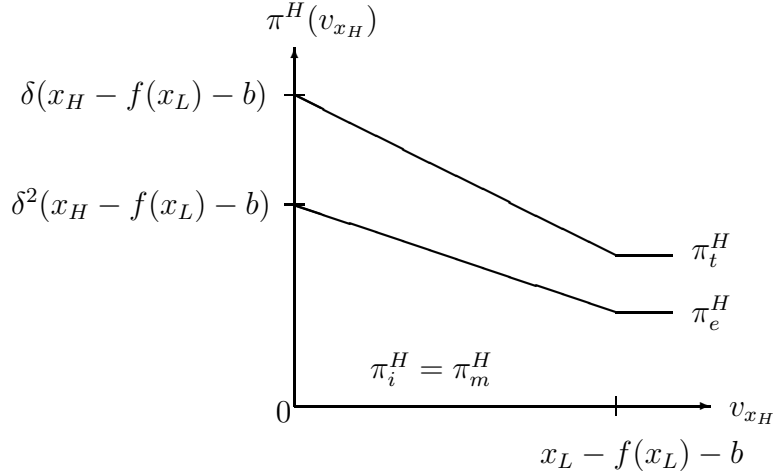


Figure 9: High Type's Utility When  $f(x_L) < x_L - b$  and  $f(x_H) = x_H - b$

Consider the case  $f(x_L) < x_L - b$ ,  $f(x_H) = x_H - b$ . The key difference to the previous case of  $f(x_E) < x_E - b$  is that  $\pi_i^H$  and  $\pi_m^H$  are equal to zero for all payouts (see Figure 9). This observation implies that given a contract  $f$ , the high type is indifferent between signaling his type and between making a payout such that the investor subsequently plays  $m$ . The reason why the high type still prefers not to signal comes from the investor's incentives when she chooses the optimal contract.

Observe that the high type either does not signal or he signals with positive probability. If he does not signal, then by the same argument as above he either mixes between paying out  $\{0, v\}$ , where  $v$  satisfies  $\pi_e^H(0) = \pi_t^H(v)$ , or he pays out zero with probability one. If he mixes between paying out  $\{0, v\}$ , then  $\pi_e^H(0) = \pi_t^H(v)$  implies  $v = (1 - \delta)(x_H - f(x_L) - b)$ . Since he does not signal, it also has to hold that  $\pi_e^L(0) = \pi_t^L(v)$ , which implies  $v = (1 - \delta)(x_L - f(x_L) - b)$ . This is a contradiction to  $v = (1 - \delta)(x_H - f(x_L) - b)$  since by assumption  $x_L < x_H$ . As a consequence, the entrepreneur pays out zero with probability one if an equilibrium exists in which he does not signal.

If the entrepreneur signals with a positive probability, he either signals with probability one or he plays a mixed strategy between making payouts that reveal his type and payouts that leave the investor uninformed. If he signals with probability one, it has to hold that the low type pays out  $v_{x_L} = 0$  and the high type pays out  $v_{x_H} = v > 0$  (see Figures 4 and 9). Otherwise, at least one type would have incentives to deviate given the other type's strategy. WLOG suppose that  $0 < v < x_L - f(x_L) - b$ . Given the low type's payout of zero, it has to hold that the investor would play  $m$  if the entrepreneur would pool his payout at zero. Otherwise, the high type would have an incentive to deviate by imitating the low type because he would get  $\pi_t^H > \pi_i^H$  or  $\pi_e^H > \pi_i^H$ . Observe

that the investor's utilities satisfy

$$\frac{\partial \pi_m^I}{\partial f(x_L)} = \delta(1 - \beta_v) < \delta = \frac{\partial \pi_t^I}{\partial f(x_L)} \quad (6)$$

and

$$\frac{\partial \pi_m^I}{\partial f(x_L)} = \delta(1 - \beta_v) < \delta^2 = \frac{\partial \pi_e^I}{\partial f(x_L)} \quad (7)$$

if  $\delta \in (0, 1)$  is sufficiently large. Equations (6) and (7) hold since the posterior  $\beta_v$  is strictly between zero and one on the left hand side because the investor would not play  $m$  if she were informed. Equations (6) and (7) show that if the investor increases  $f(x_L)$ , she becomes more likely to play  $t$  or  $e$  instead of  $m$ . If the high type signals, the investor does not have to pay monitoring costs. As a consequence, there are parameter values such that she chooses a low value of  $f(x_L)$  because the expected utility  $\pi_m^I + \delta c$  that she obtains when the entrepreneur signals is larger than  $\pi_t^I$  or  $\pi_e^I$ . She chooses a low value of  $f(x_L)$  for the following reason: a low value of  $f(x_L)$  makes the high type indifferent between payout pooling and signaling because if he would pool, the investor would play  $m$ . If the entrepreneur would not signal, the investor would choose a larger value of  $f(x_L)$  and would play  $t$  or  $e$  because she would have to pay monitoring costs when playing  $m$ . As a consequence, the high type would obtain  $\pi_t^H > 0$  or  $\pi_e^H > 0$  instead of  $\pi_i^H = 0$  if he would not signal. Therefore the high type has no incentives to make a different payout than the low type's payout  $v_{x_L} = 0$ , even if he is indifferent between  $v_{x_H} = 0$  and  $v_{x_H} > 0$  for a given contract.

Suppose the entrepreneur plays a mixed strategy between making payouts that reveal his type and payouts that leave the investor uninformed. By an argument that is analogous to the argument pertaining to the case in which the entrepreneur does not signal, it has to hold that the set of payouts that do not reveal the entrepreneur's type is equal to  $\{0\}$ . That is,  $\text{supp}(V|X = x_L) \cap \text{supp}(V|X = x_H) = \{0\}$ . Analogous to the case in which the entrepreneur signals with probability one, it has to hold that the high type makes a strictly positive payout when he signals to distinguish himself from the low type. The low type cannot signal with a strictly positive payout since he would always have an incentive to deviate by reducing his payout, given the high type's strategy (see  $\pi_i^L$  in Figure 4). As a consequence, the low type always plays  $v_{x_L} = 0$  and the high type mixes between playing  $\{0, v_{x_H}\}$ , where  $v_{x_H} > 0$ . The investor's posterior is  $\beta_0 \in (0, 1)$  and  $\beta_{v_{x_H}} = 1$ . Since the high type mixes between playing  $\{0, v_{x_H}\}$ , it has to hold that the investor plays  $m$  after observing a zero payout. Otherwise the high type would have incentives to imitate the low type by always making a zero payout since  $\pi_t^H > \pi_i^H$  and  $\pi_e^H > \pi_i^H$ . This setup is analogous to the case above in which the entrepreneur signals with probability one. As a consequence, the high type has no incentives to make a different payout than the low type's payout  $v_{x_L} = 0$ .

In summary, it is always optimal for the entrepreneur to pool his payout at zero if an equilibrium exists with  $f(x_L) < x_L - b$ ,  $f(x_H) = x_H - b$ . By the same argument

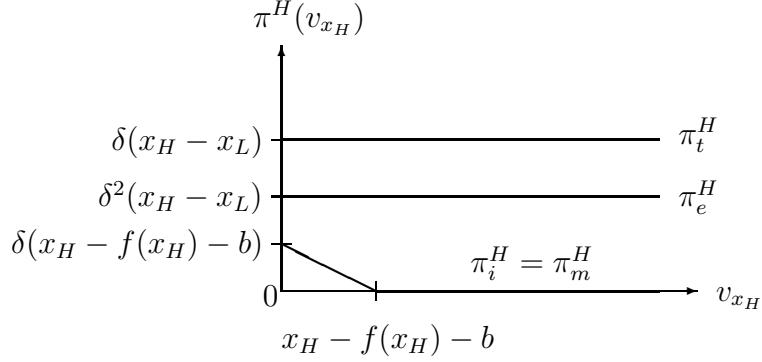


Figure 10: High Type's Utilities When  $f(x_L) = x_L - b$  and  $f(x_H) < x_H - b$

as in the case  $f(x_E) < x_E - b$ , this equilibrium cannot exist since the investor has an incentive to deviate by increasing  $f(x_L)$ .  $\square$

*Proof of Lemma 3.* The lemma's assumptions ensure that  $\theta_2$  and  $\theta_3$  are both positive. The statement  $\theta_1 \leq \theta_2$  is equivalent to  $\theta_2 \leq \theta_3$ . As a consequence, either  $\theta_1 \leq \theta_2 \leq \theta_3$  or  $\theta_3 < \theta_2 < \theta_1$ . The lemma's statement then follows immediately from the definition of the  $\Theta_j$ 's.  $\square$

*Proof of Proposition 5.* Since  $f(x_L) = x_L - b$  by Proposition 4, it follows by (3) that  $F(x_L, v) = x_L - b - v$  for all  $v \geq 0$ . The low type's utility is zero for all payouts and for all subsequent actions by the investor. That is,  $\pi_i^L = \pi_t^L = \pi_e^L = \pi_m^L = 0$  for all payouts. The low type's incentives are irrelevant relative to the high type's incentives in the following sense: all potential payout strategies of the low type are optimal given any payout strategy of the high type. In particular, the low type never objects to signaling or payout pooling. As a consequence, only the incentives of the high type determine the equilibrium. Figure 10 illustrates the high type's incentives when  $f(x_H) < x_H - b$ . If  $\delta$  is sufficiently large, (1) implies that for the high type  $\pi_m^H < \pi_e^H < \pi_t^H$  holds for all payouts.

Consider the investor's utilities. Propositions 2 and 4 imply

$$\begin{aligned} \pi_t^I &= \delta(v + (x_L - b - v) + b) \\ &= \delta x_L, \\ \pi_e^I &= \delta^2(v + (x_L - b - v) + b) + \delta(1 - \delta)\beta_v x_H \\ &= \delta^2 x_L + \delta(1 - \delta)\beta_v x_H. \end{aligned}$$

Then

$$\begin{aligned} \pi_t^I \leq \pi_e^I &\Leftrightarrow x_L \leq \delta x_L + (1 - \delta)\beta_v x_H \Leftrightarrow x_L \leq \beta_v x_H \\ &\Leftrightarrow \theta_1 \leq \beta_v. \end{aligned} \tag{8}$$

Consider a potential equilibrium with the uninformed investor playing  $m$ . If  $f(x_H) = x_H - b$ , then  $F(x_H, v) = x_H - b - v$  and

$$\begin{aligned}\pi_m^I &= \delta[v + (1 - \beta_v)(x_L - b - v) + \beta_v(x_H - b - v) + b - c] \\ &= \delta[(1 - \beta_v)x_L + \beta_v x_H - c] \\ &= \delta[(1 - \beta_v)x_L + \beta_v(f(x_H) + b) - c].\end{aligned}\tag{9}$$

Consider the case  $f(x_H) < x_H - b$  and see Figure 10 for an illustration of the high type's incentives. The following argument shows that if the investor ends up playing  $m$ , then a payout realization of zero must have occurred.<sup>17</sup> That is, the investor must have observed the event  $\{V = 0\}$ .

Suppose the game has reached a node in the extensive form that corresponds to the investor playing  $m$ . Then it has to hold that if the entrepreneur is of high type, his payout realization must have been zero. To prove that this statement holds, suppose that the high type makes a strictly positive payout. Since  $\pi_m^H$  has its unique maximum at zero and since  $\pi_m^H < \pi_e^H < \pi_t^H$  holds for all payouts, the high type has incentives to deviate by making a zero payout. By deviating, he obtains a larger utility independent of the investor's subsequent action. This is a contradiction to the assumption that the high type makes a strictly positive payout. As a consequence, it has to hold that zero is in the support of the high type's payout strategy.

It also has to hold that zero is the only element in the support of the high type's strategy. That is, the high type pays out zero with probability one. Suppose the contrary holds, that is, suppose the high type plays a mixed strategy over making a payout of zero and making nonzero payouts. Then he has to be indifferent between a payout of zero (which yields  $\pi_m^H(0) = \delta(x_H - f(x_H) - b)$ ) and a non-zero payout. However, any non-zero payout yields a utility that is either less than  $\pi_m^H(0)$  (in case the investor subsequently is informed or in case the investor monitors) or larger than  $\pi_m^H(0)$  (in case the investor plays take-it-or-leave-it or elicitation tactics). As a consequence, the high type has no incentives to play a mixed strategy. He pays out zero with probability one.

Since the investor plays  $m$ , she must have been uninformed upon receiving the payout. By the argument in the previous paragraph, she knows that if the payout was made by the high type, it must have been zero. Considering the low type, she knows that zero must be in the support of the low type's strategy, because if it would not be, she would be informed. In this sense, it has to hold that if she faces a low type, then the low type's payout realization also must have been zero (although the support of the low type's payout strategy might also include strictly positive payouts). In summary, if the investor ends up playing  $m$ , then a payout realization of zero must have occurred.

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<sup>17</sup>The logically equivalent contrapositive of this statement is: if the payout realization is strictly positive, then the investor does not play  $m$ .

With  $\beta_v = \beta_0$ , the investor's expected utility in case she plays  $m$  is therefore

$$\begin{aligned}\pi_m^I &= \delta \left[ 0 + (1 - \beta_v)(x_L - b - 0) + \beta_v F(x_H, 0) + b - c \right] \\ &= \delta \left[ (1 - \beta_v)(x_L - b) + \beta_v f(x_H) + b - c \right] \\ &= \delta \left[ (1 - \beta_v)x_L + \beta_v(f(x_H) + b) - c \right].\end{aligned}\tag{10}$$

Equations (9) and (10) imply that for all  $f(x_H) \in [f(x_L), x_H - b]$  the investor's expected utility from monitoring is

$$\pi_m^I = \delta \left[ (1 - \beta_v)x_L + \beta_v(f(x_H) + b) - c \right].$$

Comparing the investor's expected utilities yields

$$\begin{aligned}\pi_t^I \leq \pi_m^I &\Leftrightarrow x_L \leq (1 - \beta_v)x_L + \beta_v(f(x_H) + b) - c \\ &\Leftrightarrow c \leq \beta_v [f(x_H) - (x_L - b)] \\ &\Leftrightarrow \theta_2 \leq \beta_v, \\ \pi_e^I \leq \pi_m^I &\Leftrightarrow \delta x_L + (1 - \delta)\beta_v x_H \leq (1 - \beta_v)x_L + \beta_v(f(x_H) + b) - c \\ &\Leftrightarrow c - (1 - \delta)x_L \leq \beta_v [-x_L + f(x_H) + b - (1 - \delta)x_H] \\ &\Leftrightarrow \theta_3 \leq \beta_v\end{aligned}$$

if  $f(x_L) < f(x_H)$  and  $\delta$  is sufficiently close to one. By (8),  $\max\{\pi_e^I, \pi_m^I\} \leq \pi_t^I \Leftrightarrow \beta_v \in \Theta_t$ ;  $\max\{\pi_t^I, \pi_m^I\} \leq \pi_e^I \Leftrightarrow \beta_v \in \Theta_e$ ; and  $\max\{\pi_t^I, \pi_e^I\} \leq \pi_m^I \Leftrightarrow \beta_v \in \Theta_m$ . If  $f(x_L) = f(x_H)$  and  $\delta$  is sufficiently close to one, then  $\pi_m^I < \pi_t^I$  and  $\pi_m^I < \pi_e^I$  holds for all  $\beta_v \in (0, 1)$ , so monitoring is always strictly dominated.  $\square$

**Lemma 4.** *Suppose that  $\beta \in \Theta_t^c$ , where superscript  $c$  denotes the complement of a set. Then there exists a  $v \in \text{supp}(V|X = x_H)$  such that  $\beta_v \in \Theta_t^c$ .*

*Proof.* Let  $\theta := \min\{\theta_1, \theta_2\}$ . Suppose  $\beta_v \in \Theta_t$  for all  $v \in \text{supp}(V|X = x_H)$ . Then for all  $v \in \text{supp}(V|X = x_H)$  it holds by Bayes' rule that

$$\frac{\beta P(V = v|X = x_H)}{\beta P(V = v|X = x_H) + (1 - \beta)P(V = v|X = x_L)} = P(X = x_H|V = v) = \beta_v \leq \theta,$$

which implies  $\beta(1 - \theta)P(V = v|X = x_H) \leq \theta(1 - \beta)P(V = v|X = x_L)$ . By assumption,  $\beta \in \Theta_t^c$ , so both  $\theta < \beta$  and  $1 - \beta < 1 - \theta$  hold. As a consequence,  $\beta(1 - \beta)P(V = v|X = x_H) < \beta(1 - \theta)P(V = v|X = x_H) \leq \theta(1 - \beta)P(V = v|X = x_L) < \beta(1 - \beta)P(V = v|X = x_L)$ . Canceling  $\beta(1 - \beta)$  yields

$$P(V = v|X = x_H) < P(V = v|X = x_L) \quad \forall v \in \text{supp}(V|X = x_H).\tag{11}$$

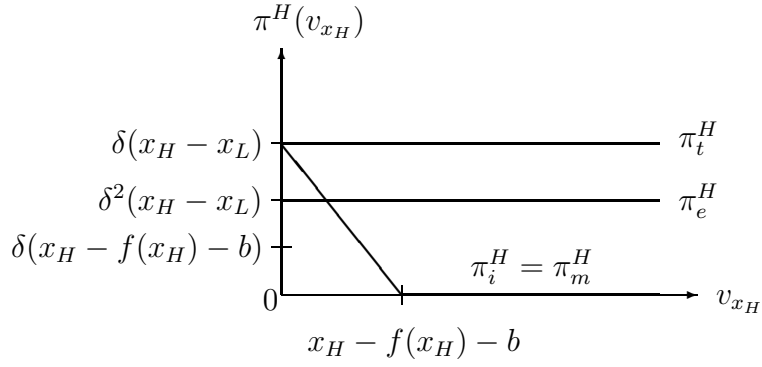


Figure 11: High Type's Utilities When  $f(x_L) = f(x_H) = x_L - b$

This inequality implies that  $P(V = v|X = x_L) > 0$  for all  $v \in \text{supp}(V|X = x_H)$ , which implies  $\text{supp}(V|X = x_H) \subseteq \text{supp}(V|X = x_L)$ . Suppose WLOG that the respective supports are discrete, otherwise replace summation with integration. Then by (11) and by  $\text{supp}(V|X = x_H) \subseteq \text{supp}(V|X = x_L)$ ,

$$\begin{aligned}
1 &= \sum_{v \in \mathbb{R}} P(V = v|X = x_H) = \sum_{v \in \text{supp}(V|X=x_H)} P(V = v|X = x_H) \\
&< \sum_{v \in \text{supp}(V|X=x_H)} P(V = v|X = x_L) \leq \sum_{v \in \text{supp}(V|X=x_L)} P(V = v|X = x_L) \\
&= \sum_{v \in \mathbb{R}} P(V = v|X = x_L) = 1.
\end{aligned}$$

As a consequence,  $1 < 1$ , a contradiction to  $\beta_v \in \Theta_t$  for all  $v \in \text{supp}(V|X = x_H)$ . Therefore there exists a  $v \in \text{supp}(V|X = x_H)$  such that  $\beta_v \in \Theta_t^c$ .  $\square$

*Proof of Proposition 6.* Throughout this proof recall that the incentives of the low type are irrelevant relative to the high type's incentives in the following sense: every payout strategy is optimal for the low type, given any payout strategy of the high type (see the beginning of Proposition 5's proof for more details). The reason for this result is that the low type always obtains zero utility, independent of her payout and independent of the investor's subsequent choice of action.

Suppose that  $f(x_H) = f(x_L)$ . Figure 11 illustrates the incentives of the high type. If  $\beta < \theta_1$ , the entrepreneur knows by Proposition 5 that if he pools his payout at, say, zero, the investor's posterior is  $\beta_0 = \beta < \theta_1$ . As a consequence, the investor plays  $t$ . Since  $\max\{\pi_i^H, \pi_m^H, \pi_e^H\} \leq \pi_t^H$  holds for all payouts, pooling at zero is optimal. If  $\beta \geq \theta_1$ , then signaling with  $(v_{x_L}, v_{x_H}) = (w, 0)$  is optimal, where  $w > 0$ . Signaling is optimal since the high type obtains  $\pi_i^H(0) = \delta(x_H - x_L)$  and since  $\max\{\pi_i^H, \pi_m^H, \pi_t^H, \pi_e^H\} \leq \delta(x_H - x_L)$  holds for all payouts.

Suppose that  $f(x_H) > f(x_L)$ . Figure 10 illustrates the incentives of the high type. For all payouts it holds that  $\pi_i^H = \pi_m^H < \pi_e^H < \pi_t^H$  since  $\delta \in (0, 1)$  is sufficiently large.

In the following argument I partially focus on interior sets to avoid that the uninformed investor is indifferent between two or more alternatives (say, between playing  $t$  and  $m$ ). If  $\beta \in \Theta_t^o$ , then payout pooling at zero yields the posterior  $\beta_0 = \beta \in \Theta_t^o$ . The investor plays  $t$  and the high type obtains  $\pi_t^H$ . Since  $\pi_t^H$  maximizes the high type's utility and since the low type obtains zero utility in any case, it is optimal for the entrepreneur to pool his payout.

If  $\beta \in \Theta_e^o$ , payout pooling at zero makes the investor play  $e$  since  $\beta_0 = \beta \in \Theta_e^o$ . Since  $\pi_t^H = \pi_m^H < \pi_e^H$  holds for all payouts, payout pooling strictly dominates signaling. Payout pooling also dominates playing a payout strategy such that the investor plays  $m$ .

The high type prefers the investor to play  $t$  instead of  $e$ . However, he cannot play a payout strategy such that the investor plays  $t$ . To prove that this statement holds, consider the following argument. The only way the high type can make the investor play  $t$  is by playing a payout strategy such that he makes with positive probability a payout  $v$  with  $\beta_v \in \Theta_t$ . Suppose such a strategy exists. Since by assumption  $\beta \in \Theta_t^c$ , Lemma 4 implies that with positive probability the high type also has to make payouts such that the investor updates to a posterior in  $\Theta_t^c$  and therefore does not play  $t$ . As a consequence, the high type randomizes over payouts that yield the utility  $\pi_t^H$  and payouts that yield a utility strictly less than  $\pi_t^H$ . This is a contradiction because the high type can only randomize over payouts that yield identical utility levels. In this sense, there is no strategy such that the high type can make the investor play  $t$ . As a consequence, the entrepreneur pools his payout at zero and the investor plays  $e$ .

If  $\beta \in \Theta_t \cap \Theta_e$ , then by the same reasoning as above the entrepreneur's best reply is to pool his payout at zero. As a consequence, it holds that the entrepreneur's best reply is to pool his payout at zero whenever  $\beta \in (\Theta_t \cup \Theta_e)^o$ .

If  $\beta \in \Theta_m$ , then in analogy to the argument from Lemma 4, there is no equilibrium with a payout strategy such that the investor plays  $t$  or  $e$ . As a consequence, the entrepreneur either pools his payout at zero or he signals with  $(v_{x_L}, v_{x_H}) = (w, 0)$ . In both cases the entrepreneur obtains the same utility: if he pools at zero, the investor updates to  $\beta_0 = \beta \in \Theta_m$  and plays  $m$ . As a consequence, the entrepreneur plays a (potentially degenerate) mixed strategy over payout pooling and signaling.

Observe that the investor plays  $m$  with probability one whenever  $\beta = \min \Theta_m$  (and  $\min \Theta_m$  exists). Therefore this lemma's statement does not only pertain to the interior of  $\Theta_m$  but to the whole of  $\Theta_m$ . The reason why it is optimal for the investor to play  $m$  whenever  $\beta = \min \Theta_m$  is as follows. Suppose that  $\min \Theta_m = \max \Theta_e$  (the same argument goes through in analogy for the case  $\min \Theta_m = \max \Theta_t$ ). Then the investor is indifferent between playing  $m$  and playing  $e$  in case the entrepreneur pools his payout. The investor, however, would like the entrepreneur to signal because the investor does not pay monitoring costs in case she is informed. If the investor plays  $e$  after payout pooling, then it is strictly suboptimal for the entrepreneur to signal. Instead, he pools his payout at zero. If the investor plays  $m$  after payout pooling, then the entrepreneur is indifferent between payout pooling and signaling. He plays a mixed strategy over

payout pooling and signaling. The investor is informed with positive probability. In this sense, she increases her expected utility since she does not pay monitoring costs with positive probability. As a consequence, it is optimal for the investor to play  $m$  whenever  $\beta = \min \Theta_m$ .  $\square$

**Lemma 5** (Investor's Ex Ante Expected Utility in Case  $\beta \in \Theta_m$ ). *Assume that discounting is sufficiently moderate. Let  $\Pi_m^I$  denote the investor's ex ante expected utility when  $\beta \in \Theta_m$ . By Propositions 5 and 6 the entrepreneur plays a mixed strategy with mixing probability  $\zeta$ . In this case the following holds. The probability*

$$\beta_0 = \frac{\beta}{1 - (1 - \beta)\zeta}$$

is the investor's posterior after observing the event  $\{V = 0\}$ . For all  $\zeta < 1$ , the investor's expected utility is

$$\Pi_m^I(\zeta, f(x_H)) = \delta \left[ (1 - \beta)\zeta x_L + [1 - (1 - \beta)\zeta] [(1 - \beta_0)x_L + \beta_0(f(x_H) + b) - c] \right],$$

and for  $\zeta = 1$ ,

$$\Pi_m^I(1, f(x_H)) = \delta \left[ (1 - \beta)x_L + \beta(f(x_H) + b) \right].$$

*Proof.* Recall that the entrepreneur plays  $(v_{x_L}, v_{x_H}) = (w, 0)$  with probability  $\zeta$  and he plays  $(v_{x_L}, v_{x_H}) = (0, 0)$  with probability  $1 - \zeta$ , where  $w > 0$ . As a consequence, the investor's posterior is  $\beta_w = 0$  and

$$\beta_0 = P(X = x_H | V = 0) = \frac{P(V = 0 | X = x_H)\beta}{P(V = 0)} = \frac{\beta}{1 - (1 - \beta)\zeta}$$

since  $P(V = 0) = P(V = 0 | X = x_H)\beta + P(V = 0 | X = x_L)(1 - \beta) = \beta + (1 - \zeta)(1 - \beta) = 1 - \zeta(1 - \beta)$ . Observe that  $\beta_0 = \beta$  when  $\zeta = 0$  and  $\beta_0 = 1$  when  $\zeta = 1$ . That is, the entrepreneur does not release new information if he plays  $\zeta = 0$  and he reveals his type when  $\zeta = 1$ . Since  $\beta_0$  is increasing in  $\zeta$ , since  $\beta \in \Theta_m$ , and since  $\hat{\beta} \in \Theta_m$  for all  $\hat{\beta} \in [\beta, 1)$  it holds that  $\beta_0 \in \Theta_m$  for all  $\zeta \in [0, 1)$ .

The investor's ex ante expected utility obtains as follows. With probability  $P(V = w) = 1 - P(V = 0) = (1 - \beta)\zeta$  the investor is informed and knows that she faces the low type. By proposition 1, she obtains  $\delta x_L$ . If  $\zeta < 1$ , then with probability  $P(V = 0) = 1 - (1 - \beta)\zeta$  the investor is uninformed, updates to  $\beta_0 \in \Theta_m$ , monitors, and obtains  $\pi_m^I = \delta [0 + (1 - \beta_0)(x_L - b) + \beta_0 f(x_H) + b - c] = \delta [(1 - \beta_0)x_L + \beta_0(f(x_H) + b) - c]$ . As a consequence, when  $\zeta < 1$ , the investor's ex ante expected utility is

$$\Pi_m^I(\zeta, f(x_H)) = P(V = w) \cdot \delta x_L + P(V = 0) \cdot \delta [(1 - \beta_0)x_L + \beta_0(f(x_H) + b) - c],$$

which is equal to the expression given in the lemma.

Suppose that  $\zeta = 1$ . With probability  $P(V = w) = 1 - \beta$  the investor observes a payout such that she updates to  $\beta_w = 0$  and therefore knows ex post that she faces the low type. That is, with probability  $1 - \beta$  she obtains  $\delta x_L$  by Proposition 1. Similarly, with probability  $P(V = 0) = 1 - P(V = w) = \beta$  she observes a payout such that she updates to  $\beta_0 = 1$  and therefore knows ex post that she faces the high type. That is, with probability  $\beta$  she obtains  $\delta(f(x_H) + b)$  by Proposition 1. As a consequence, the investor's ex ante expected utility is

$$\begin{aligned}\Pi_m^I(1, f(x_H)) &= P(V = w) \cdot \delta x_L + P(V = 0) \cdot \delta(f(x_H) + b) \\ &= \delta[(1 - \beta)x_L + \beta(f(x_H) + b)].\end{aligned}\quad \square$$

**Lemma 6** (Properties of  $\Pi_m^I$ ). *The function  $\Pi_m^I$  is strictly increasing in  $\zeta$  and  $f(x_H)$ . It is continuous in  $\zeta$  on the interval  $[0, 1)$  and exhibits a jump upwards at  $\zeta = 1$ .*

*Proof.* The function is strictly increasing in  $\zeta$  on  $[0, 1)$  since  $\partial\Pi_m^I/\partial\zeta = \delta(1 - \beta)c > 0$ . It is strictly increasing in  $\zeta$  on  $[0, 1]$  since  $\lim_{\zeta \rightarrow 1^-} \Pi_m^I(\zeta, f(x_H)) = \delta[(1 - \beta)x_L + \beta(f(x_H) + b) - c] < \Pi_m^I(1, f(x_H))$ . The function is strictly increasing in  $f(x_H)$  since  $\partial\Pi_m^I/\partial f(x_H) = \delta\beta > 0$ .  $\square$

*Proof of the Main Theorem.* This proof considers the two cases  $\beta < \theta_1$  and  $\beta \geq \theta_1$  separately. First, suppose that  $\beta < \theta_1$ . As a consequence, the uninformed investor never plays  $e$  and instead decides between playing  $t$  and  $m$  (see Propositions 5 and 6). That is,  $\beta \in \Theta_t$  or  $\beta \in \Theta_m$ . With  $\lambda := f(x_L) + c/\beta$  and  $M := [\lambda, x_H - b]$  it then holds that

$$\beta \in \Theta_m \quad \Leftrightarrow \quad f(x_H) \in M, \quad (12)$$

since  $\theta_2 \leq \beta$  is equivalent to  $\lambda \leq f(x_H)$ . The definition of  $M$  implies

$$M = \emptyset \quad \Leftrightarrow \quad \beta < \underline{\beta}. \quad (13)$$

If  $f(x_H) = f(x_L)$ , then by Propositions 5 and 6 the entrepreneur pools<sup>18</sup> his payout at zero, the investor plays  $t$  and obtains  $\pi_t^I = \delta x_L$ .

Suppose the game's parameters are such that  $\beta < \underline{\beta}$ . That is,  $M = \emptyset$  and there exists no  $f(x_H) \in [f(x_L), x_H - b]$  such that  $\beta \in \Theta_m$ . Independent of the value of  $f(x_H)$ , the entrepreneur pools at zero and the investor plays  $t$ . Since  $f(x_L) = x_L - b$ , it follows that  $\pi_t^I = \delta x_L$  for all  $f(x_H)$ . As a consequence, it is optimal for the investor to set  $f(x_H) = f(x_L)$ . Assigning monitoring rights to the contract does not increase the investor's utility: she would not monitor and would not use the threat of monitoring even if she would have monitoring rights.

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<sup>18</sup>If the entrepreneur would instead signal (see Remark 2), the investor's expected utility would also be  $\delta x_L$ . In this sense, the entrepreneur cannot "reward" the investor for choosing  $f(x_H) = f(x_L)$  by signaling.

Suppose the game's parameters are such that  $\beta = \underline{\beta}$ . That is,  $M = \{x_H - b\}$  and therefore  $\beta \in \Theta_m$  if and only if  $f(x_H) = x_H - b$ . Observe that

$$\Pi_m^I(0, x_H - b) = \delta[(1 - \beta)x_L + \beta[(x_H - b) + b] - c] = \delta[(1 - \beta)x_L + \beta x_H - c] = \delta x_L$$

since  $\beta = \underline{\beta}$  implies  $c = \beta(x_H - x_L)$ . Lemma 6 implies that  $\Pi_m^I(\zeta, x_H - b) \geq \delta x_L = \pi_t^I$  for all  $\zeta \in [0, 1]$ . Since the investor gets  $\pi_t^I$  if she sets  $f(x_H) \in [f(x_L), x_H - b)$ , it is optimal for the investor to play  $f(x_H) = x_H - b = x_L - b + c/\beta$ . The last identity holds since  $\beta = \underline{\beta}$ . Since the entrepreneur knows that the investor plays  $f(x_H) = x_H - b$  independent of his signaling probability, it is optimal for him to signal since he is indifferent between signaling and payout pooling.

Suppose the game's parameters are such that  $\beta > \underline{\beta}$ . That is,  $\lambda < x_H - b$  and the interval  $M$  has positive length. By playing  $f(x_H) \in M$ , the investor can obtain at least  $\Pi_m^I(0, x_H - b) = \delta[(1 - \beta)x_L + \beta x_H - c]$  since by Lemma 6,  $\Pi_m^I$  is increasing in  $f(x_H)$  and since the entrepreneur's maximal punishment consists of playing  $\zeta = 0$ . Since  $\beta > \underline{\beta}$  implies  $c < \beta(x_H - x_L)$ , it holds that  $\Pi_m^I(0, x_H - b) > \delta x_L = \pi_t^I$ . As a consequence, it is always optimal for the investor to play  $f(x_H) \in M$ .

Knowing that the investor plays  $f(x_H) \in M$ , the entrepreneur plays a trigger strategy in the following sense. If the investor chooses a large value of  $f(x_H)$ , the entrepreneur plays maximal punishment by setting  $\zeta = 0$ . If the investor chooses a low value of  $f(x_H)$ , the entrepreneur rewards the investor by signaling with probability one. That is, the entrepreneur plays the trigger strategy

$$\zeta_l(f(x_H)) := \mathbb{1}(f(x_H) \leq l), \quad (14)$$

where  $l$  denotes the threshold level and  $\mathbb{1}$  denotes the indicator function. Figure 12 illustrates the investor's expected utility  $\Pi_m^I$  when the entrepreneur plays the trigger strategy  $\zeta_l$ . The entrepreneur chooses the threshold level  $l$  as small as possible such that it is still optimal for the investor to play  $f(x_H) = l$ . That is, the entrepreneur chooses the smallest threshold level  $l \in M$  such that  $\Pi_m^I(0, x_H - b) \leq \Pi_m^I(1, l)$  still holds.

Suppose that  $\Pi_m^I(0, x_H - b) \leq \Pi_m^I(1, \lambda)$ , that is,  $\beta \leq \bar{\beta}$ . In this case it is optimal for the entrepreneur to play  $l = \lambda$ . In equilibrium, the investor plays  $f(x_H) = \lambda$  and the entrepreneur signals with probability one. Although the investor does not monitor in equilibrium, she still assigns monitoring rights to the contract. To show that this claim is true, suppose that the investor does not assign monitoring rights. Then she plays  $t$  or  $e$  in case the entrepreneur pools. In particular, she does not play  $m$  after payout pooling. The entrepreneur plays the trigger strategy  $\zeta_l$  only if he is indifferent between signaling and payout pooling for a given contract. He is only indifferent if the investor plays  $m$  after payout pooling. Since the investor does not play  $m$  after payout pooling, the entrepreneur is no longer indifferent and therefore does not play the trigger strategy  $\zeta_l$ . Instead, he pools his payout (see Proposition 6 with  $\Theta_t$  and  $\Theta_e$  replaced

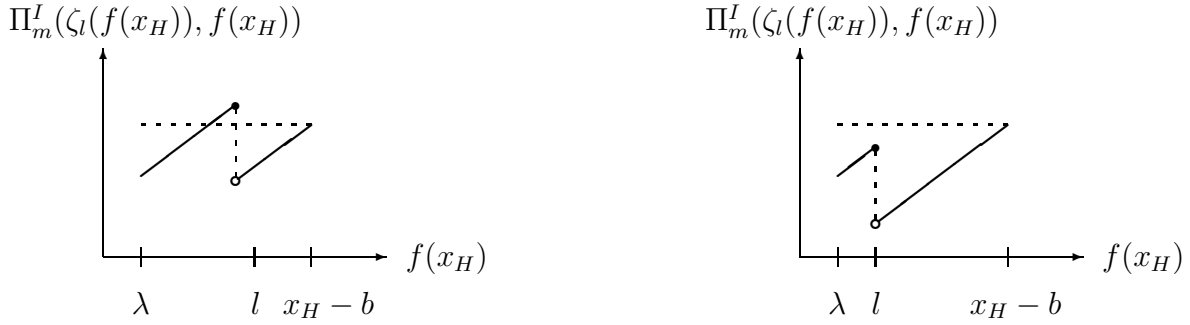


Figure 12: On the left hand side, the entrepreneur's threshold level  $l$  is sufficiently large such that it is optimal for the investor to play  $f(x_H) = l$ . On the right hand side, the threshold level  $l$  is too small to give the investor incentives to play  $f(x_H) = l$ . Instead, the investor plays  $f(x_H) = x_H - b$ .

by  $(0, \theta_1] \cap (0, 1)$  and  $[\theta_1, 1) \cap (0, 1)$  and with  $\Theta_m = \emptyset$ ). The investor's expected utility is lower when the entrepreneur conceals information by pooling his payout than when the entrepreneur reveals information by signaling. As a consequence, it cannot be an equilibrium that the investor does not assign monitoring rights since this strategy is suboptimal.

Suppose that  $\Pi_m^I(1, \lambda) < \Pi_m^I(0, x_H - b)$ , that is,  $\bar{\beta} < \beta$ . In this case it is optimal for the entrepreneur to play  $l > \lambda$  such that  $\Pi_m^I(1, l) = \Pi_m^I(0, x_H - b)$ . Such an  $l$  exists by Lemma 6 and is given by  $l = x_H - b - c/\beta$ . In equilibrium, the investor plays  $f(x_H) = x_H - b - c/\beta$  and the entrepreneur signals with probability one. By the same argument as in the previous paragraph, the investor assigns monitoring rights to the contract.

Second, suppose that  $\theta_1 \leq \beta$ . Playing  $t$  is dominated by playing  $e$  and as a consequence,  $\beta \notin \Theta_t^o$ . Therefore  $\beta \in \Theta_e$  or  $\beta \in \Theta_m$ . With

$$\hat{\lambda} := f(x_L) + c/\beta + (1 - \delta)(x_H - x_L/\beta), \quad \hat{M} := [\hat{\lambda}, x_H - b]$$

it then holds that

$$\beta \in \Theta_m \Leftrightarrow f(x_H) \in \hat{M}, \quad (15)$$

since  $\theta_3 \leq \beta$  is equivalent to  $\hat{\lambda} \leq f(x_H)$  for sufficiently large  $\delta \in (0, 1)$ . The definition of  $\hat{M}$  implies

$$\hat{M} = \emptyset \Leftrightarrow \beta < \underline{\beta}'. \quad (16)$$

As indicated by this notation, the analysis proceeds in analogy to the case of  $\beta < \theta_1$ . If  $f(x_H) = f(x_L)$ , then by Propositions 5 and 6 the entrepreneur signals his type. The investor's expected utility is  $\delta x_L$ .

Suppose the game's parameters are such that  $\beta < \underline{\beta}'$ . That is, there exists no  $f(x_H) \in [f(x_L), x_H - b]$  such that  $\beta \in \Theta_m$ . By Proposition 6, the entrepreneur plays

payout pooling at zero for all choices of  $f(x_H) > f(x_L)$  and the investor obtains  $\pi_e^I = \delta^2 x_L + \delta(1 - \delta)\beta x_H > \delta x_L$ . As a consequence, the investor plays  $f(x_H) > f(x_L)$ , say  $f(x_H) = f(x_L) + 2(1 - \delta)(x_H - x_L)$ , and the entrepreneur pools his payout. As in the case of  $\beta < \theta_1$ , the investor does not assign monitoring rights to the contract.

Suppose the game's parameters are such that  $\beta = \underline{\beta}'$ . That is,  $\beta \in \Theta_m$  if and only if  $f(x_H) = x_H - b$ . Then

$$\Pi_m^I(0, x_H - b) = \delta[(1 - \beta)x_L + \beta x_H - c] = \delta^2 x_L + \delta(1 - \delta)\beta x_H \geq \delta x_L$$

since  $c = \beta(x_H - x_L) - (1 - \delta)(\beta x_H - x_L)$  and  $\theta_1 \leq \beta$ . As a consequence of Lemma 6, it is optimal for the investor to play  $f(x_H) = x_H - b = f(x_L) + c/\beta + (1 - \delta)(x_H - x_L/\beta)$ . The last identity holds since  $\beta = \underline{\beta}'$ . Knowing that the investor plays  $f(x_H) = x_H - b$  independent of the choice of  $\zeta \in [0, 1]$ , it is optimal for the entrepreneur to signal with probability one.

Suppose the game's parameters are such that  $\underline{\beta}' < \beta$ . That is,  $\hat{\lambda} < x_H - b$  and the interval  $\hat{M}$  has strictly positive length. Since  $c < \beta(x_H - x_L) - (1 - \delta)(\beta x_H - x_L)$ , it holds that  $\Pi_m^I(0, x_H - b) > \delta x_L$ . As a consequence, it is always optimal for the investor to play  $f(x_H) \in \hat{M}$ . With

$$\Pi_m^I(0, x_H - b) \leq \Pi_m^I(1, \hat{\lambda}) \quad \Leftrightarrow \quad \beta \leq \bar{\beta}',$$

the remainder of this proposition's statement follows in analogy to the case  $\beta < \theta_1$  with  $\lambda$  replaced by  $\hat{\lambda}$ . Also note that  $\lambda \leq \hat{\lambda}$  since  $\theta_1 \leq \beta$ . As a consequence,  $f(x_H) \geq \lambda$  whenever  $\underline{\beta}' \leq \beta$ .  $\square$

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