

POSTURING IN VENTURE CAPITAL

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January 23, 2015

ABSTRACT. We show how a VC's need to "posture" solves the commitment problem inherent in stage financing. Posturing arises when a VC needs to send a strong signal to induce skeptical third parties to take actions that increase firm value. This is accomplished by investing at high prices in later rounds, which credibly conveys the VC's confidence. Posturing effectively shifts bargaining power toward the entrepreneur, inducing greater entrepreneurial effort *ex ante*. We show that posturing causes overpricing relative to fundamentals, and provide novel predictions for price dynamics, the probability of receiving funding, and *ex post* success rates.

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1. INTRODUCTION

When complete contracts are difficult or impossible to write, multi-stage relationships can be vulnerable to hold-up problems. This decreases the parties' willingness to make relationship-specific investments, so committing to refrain from hold up is often critical to success. In this paper we show that the need to signal private information to less informed third parties can act as a natural commitment device. If the party with the power to engage in hold up also possesses private information, the outcomes of later stage (re-)negotiations are likely to influence third parties' beliefs and consequently their actions. The need to send a strong signal to influence third party actions can therefore change the nature of later stage negotiations. For example, an informed party who would otherwise impose onerous terms has an incentive to relax those terms to credibly signal that their information is good, i.e., to show that even when entering into a deal with relatively generous terms they expect to realize greater surplus since the relationship's potential value is especially high. In this way, the need to signal and create a feedback loop between contracting terms and third party actions tempers hold up.

This general idea could be applied to multi-stage relationships in many different settings, such as financing relationships, joint ventures, alliances, customer-supplier relationships, etc. We focus our analysis on venture capital, which is a natural application because of the multi-stage nature of the financing relationship between a startup and its VC. Stage financing is popular in venture capital both because it solves the moral hazard problem of the entrepreneur at the earlier stages, and because it allows a VC to reassess the prospects and financing needs of its portfolio firms at intermediate stages to prevent over or under-investment. However, since later rounds generally involve new contract negotiations (Gompers, 1995), this creates the possibility of ex-post opportunism, as suggested by Gilson and Black (1998):

What can the entrepreneur do if the venture capitalist opportunistically offers to provide the second-stage financing necessary for the entrepreneur to continue at an unfair price? The entrepreneur could seek financing from other sources, but....who would incur the costs of making a bid when potential bidders know that a bid will succeed only when a better informed party – the original investor – believes the price is too high?”¹

Similarly, Gilson (2003) notes that while stage financing may reduce agency costs related to entrepreneurial actions, it clearly shifts the potential for opportunistic action to the VC. This can be exacerbated by the fact that, after the innovation stage is essentially complete, the marginal value of the entrepreneur’s future contribution decreases while that of the VC increases (since it still needs to provide additional financing to create a market for the innovation and/or help professionalize the firm). Anticipating this future hold-up, the entrepreneur is less likely to work hard at completing the innovation at the earlier stage, thereby defeating the very purpose of stage financing.²

¹Similar possibilities have been noted in relationship banking, e.g., Sharpe (1990) and Rajan (1992).

²See also Admati and Pfleiderer (1994), Fluck, Garrison, and Myers (2005), Atanasov, Ivanov, and Litvak (2012), and Broughman and Fried (2012), for discussions of the potential for ex post opportunism by VCs. An important legal precedent in this area is *Kalashian v. Advent*, in which the VC invested in a later round at a very low valuation and subsequently sold the firm for a much larger amount, prompting the founders to sue for breach of fiduciary duty with respect to the price paid in the financing round. The case was ultimately settled, but established the potential for liability for VCs who were too aggressive in pressing their bargaining advantage at later stage financings. See Cowley and Pike (2003) and Surpure (2008) for examples of practitioner advice regarding potential liability in these situations. Note that while legal recourse may somewhat constrain the scope for hold up, it is likely not sufficient to eliminate it, or to explain the steeply increasing price paths often observed in later rounds. Our model describes a self-enforcing mechanism that can do both.

However, since startup firms usually develop new products and/or new markets, their prospects are particularly dependent on how they are perceived by less informed third parties. These include potential competitors who might contest the new market, as well as key employees needed to develop the new product, and the suppliers, consumers, third party vendors and investors needed to grow the firm and make it successful. Since information about a startup's prospects is generally limited to those close to the firm, the terms of later stage financing may be critical to relaying the information to third parties in a credible way. Thus, the more the VC pays for an additional stake in the firm, the stronger the signal to the market and the more likely is the VC to induce desired actions by third parties.³ In this sense, late round VC financing contracts serve the dual purpose of not only allocating surplus between the entrepreneur and the VC, but also creating a feedback loop in which high prices in later rounds induce third party actions that make the firm more valuable. We show that this latter role constrains the VC's ability to expropriate the entrepreneur's rents and thus provides the commitment necessary to elicit the desired ex ante effort from the entrepreneur.

We derive these results in a simple two-stage model. An entrepreneur has a promising idea and needs capital from a VC to develop an innovation. Successful development depends on the amount of effort expended by the entrepreneur. The entrepreneur is aware that once the innovation is completed, he will have to choose between an early exit (e.g., selling the firm to a strategic buyer such as an established firm in a related market) and a potentially much more valuable but riskier late exit (probably through an IPO in the future). If a late exit is chosen he will need intermediate financing from his existing VC, at which point the bargaining power will shift to the VC. The late exit (IPO) strategy is risky both because there

³Pricing high is equivalent to signaling a high post-money value, which is equivalent to signaling a high pre-money value, the term generally favored by practitioners.

is a chance the firm’s fundamentals will not be good enough, and because success depends on third parties’ beliefs about the firm’s fundamentals.

As a counterfactual, if third party actions are not critical or they receive sufficient information on their own about firm fundamentals, then the VC does not need to signal and is free to exploit its bargaining power in the second stage financing round, resulting in the hold up problem discussed above. However, if third party actions are critical and the information on fundamentals is private information of the VC, a natural way to credibly signal this information is through the terms of the second-stage financing contract, i.e., by investing in the second stage at a high pre-money value (demanding a smaller share for a given investment), or “posturing.”^{4,5} In fact, we show that when posturing is required, the pre-money value at which the VC invests in the second stage is sometimes even higher than its private information can justify, which is in contrast to the usual result that a VC with substantial bargaining power should be able to demand significant underpricing.

The VC is willing to over-pay when the feedback loop it creates from high prices to third party actions increases the value of its initial stake in the firm by more than the expected cost of overpayment. Thus, posturing leads to overpricing only when the VC holds a significant first round stake. Also, the degree of overpricing is increasing in the initial stake. While the third parties are not fooled in equilibrium when the VC postures, the compulsion to overprice restricts the VC’s ability to exploit its bargaining power against the entrepreneur.

⁴The idea that information on fundamentals could be private information of the VC is consistent with empirical evidence about the role of VCs in advising and managing portfolio firms – see Hellmann and Puri (2000, 2002), and Lerner (1995).

⁵We use the term posturing to distinguish from standard signaling since the signal in our model includes a pricing element that is not always present in standard models. In particular, the observed pricing of the second stage investment often exceeds what would be justified by either the VC’s private information *or* the third parties’ quality inference.

This allows the entrepreneur to capture a larger proportion of the rents ex post despite the shift in bargaining power toward the VC. As a result, ex ante contracting is more efficient and elicits greater effort from the entrepreneur at the innovation stage, resulting in higher firm value.

Our result that the need to posture often leads to overpricing in the later rounds is consistent with empirical observations that VCs sometimes invest at valuation levels that do not seem to reflect the reality of the underlying situation. Gompers and Lerner (2000, 2001) and Sahlman and Stevenson (1987) discuss the fact that VC valuations tend to look high (resulting in apparently low returns) in particular industries at certain times, and relate this to the amount of money being invested by limited partners at those times. In addition, practitioners and the popular press often note episodes when VC valuations seem unsustainably high, such as during the late 1990s internet boom, or the recent boom in social media startups.⁶ Our results provide a new explanation for why valuations may look high at certain times, particularly when third party skepticism or competitor aggressiveness makes it more difficult to create the conditions necessary for a successful exit.⁷

Our model also provides a number of interesting comparative statics with respect to pricing across different venture capital rounds. First, when compared with situations where hold up occurs, a steeper upward price path across rounds is expected when posturing occurs. Posturing is also expected to be associated with a higher probability of initial funding and

⁶See, e.g., Malik (2012), Carlson (2012), and Stone (2012) for discussions of recent high VC valuations of social media and other internet firms.

⁷Note that while prices may exceed fundamentals in our model, third parties are never fooled, i.e., their inference based on the prices is, on average, correct. Thus, our model cannot explain episodes of true overvaluation, where investors and third parties misperceive the value of firms on average. However, it can help explain why calculated prices appear to be high in some situations, which can create or enhance the *appearance* of a price bubble.

greater ex post success rates. In addition, as third parties become more skeptical about firm prospects (or when competitors are harder to scare away), the VC demands a lower second stage stake, i.e., later stage pricing rises. In addition, with increasing skepticism the range of states over which second period funding is valuable decreases. Thus, less equilibrium effort is desired, which is accomplished by increasing the VC's first round stake. This increase in the VC's first round stake amplifies the increase in the second round price due to higher skepticism, because a higher initial stake makes it harder to signal. Finally, an increase in the potential severity of the hold up problem, proxied by an increased difference in the profitability of a late versus early exit, also implies a steeper pricing path when posturing is necessary relative to situations where hold up occurs.

The feedback effect in which prices impact the behavior of third parties plays a critical role in our paper, as it does in Subrahmanyam and Titman (2001), Goldstein and Guembel (2008), Khanna and Mathews (2012), and others, which argue that a firm's stock price affects how the firm is perceived by its customers, suppliers, employees, competitors, lenders, and other stakeholders.⁸ In turn these perceptions influence purchase, supply, market entry and investment decisions connected with the firm or its market, which feeds back into the firm's cashflow.

The unique element of the feedback effect in our paper is that the prices are not set in an arm's length financial market, but instead in a negotiation between the firm and its VC. We believe that price signals revealed in VC financing rounds are especially consequential as they are the most likely source of information to third parties about the future prospects of

⁸Also see Leland (1992), Khanna, Slezak, and Bradley (1994), Dow and Gorton (1997), Ozdenoren and Yuan (2008), and Goldstein, Ozdenoren, and Yuan (2013), Khanna and Sonti (2004), and Attari, Banerjee, and Noe (2006) for theoretical studies involving feedback effects. Baker, Stein, and Wurgler (2003), Durnev, Morck, and Yeung (2004), Luo (2005), Sunder (2004), Bakke and Whited (2010), Chen, Goldstein, and Jiang (2007), and Edmans, Goldstein, and Jiang (2012) provide related empirical evidence.

privately held startups. A committed VC paying high prices is a powerful signal about its confidence in the firm's prospects.

1.1. Motivating Examples. As an example of a market where posturing seems to affect VC valuations, consider the situation currently playing out in the ride-sharing space. Since 2011, three players have taken the lead to develop this space: Uber, Lyft, and Sidecar. Until the beginning of 2013, they were running head-to-head. In May 2013, the VC firm Andreessen-Horowitz shook up the market by buying about 20% of Lyft for \$60M, placing its value at \$275M. This investment and its terms were widely reported in the media, and the valuation was considered surprisingly high by many, including management and investors at competing firm Sidecar. This had the immediate effect of freezing Sidecar's access to the capital markets, which weakened its competitive position. A typical response from potential investors looked something like this:

While [we] were very impressed with you and the growth trajectory you are on, we are going to pass on the opportunity. Our concern is that the amount of capital it will take to compete in this space is quickly becoming greater than what we'd have appetite for based on the progress to date. In a perfect world, we wouldn't have irrational players out there messing things up! But unfortunately, the idea of going up against two very well-funded, shoot for the moon type of competition is very hard and costly to overcome, and frankly gives us too much pause to proceed here.

The reference to "irrational players" is a strong indication that the valuation was higher than seemed rational to this particular investor.

In response, in August 2013, Uber sold \$350M worth of shares at a valuation of \$3.5B (Swisher, 2013). Apparently, the aggressive valuation accorded to Uber by its investors signaled that Uber was now considered the front runner in this space. This severely limited

Lyft's ability to raise additional funds, and even though Lyft raised an additional \$250m, it was at a pre-money valuation of only around \$700M (De La Merced, 2014). Fortune noted "The company [Lyft] did not disclose valuation, but CEO Logan acknowledged that earlier reports of a \$700M pre-money mark were in the right general ballpark" (Primack, 2014). Understandably, Lyft was reluctant to reveal the low pre-money value reflected in this deal as it would signal weakness even though it was not technically a down round.

Uber, though, soon removed any doubt in the market as to who was being anointed to lead the space. In June 2014, Uber issued an additional \$1.2B of stock at an astonishing pre-money value of \$17B (Saitto and Stone, 2014), even though it apparently did not need these funds at this time. The reasoning was summed up by Yarow (2014): "[Uber CEO Travis Kalanick] wants to snuff out Lyft because it's the biggest threat to Uber's plans to take over the world." Apparently, the market believed there was a degree of posturing by Uber's investors to make the signal a very strong one. According to Saitto and Stone (2014), "some VC and PE investors bailed out [of the offering] after the valuation soared beyond \$10B."

Uber reportedly used some of its newfound capital to provide monetary incentives to drivers and passengers to switch to Uber from Lyft (Soper, 2014). Apparently a strong financing round by Uber, and a weak one by Lyft, left Lyft vulnerable to defections by its own employees and customers, further worsening its prospects.

In this anecdote we see two different effects that are in line with the basic premise underlying our model. First, appropriately large investments at high prices can discourage competitors and/or their investors and create a self-fulfilling competitive advantage. Second, a financing round with a low valuation can have a negative effect on a firm's own prospects as employees, customers, or suppliers become wary. Indeed, Shontel (2013) reports that down-rounds and low price levels can be very demoralizing for employees because it reduces the perceived

probability that the firm will survive in a competitive market. Conversely, therefore, an up-round with a high valuation can help avoid such problems and make attracting and retaining employees, customers, and suppliers much easier.

When social media startup LivingSocial completed a financing round at a disappointing valuation in February of 2013, reporting of the terms of the deal prompted the CEO to send out a memo to reassure employees, apparently to prevent departures and loss of morale. In the memo, the CEO specifically encouraged employees not to focus on the low valuation and suggested that many people are “overly enamored” with market value signals (Lawler, 2013). Similar events occur when public company stock prices fall. A report titled “As Zynga stock price plummets, company hemorrhaging top talent” states that “since its December 2011 IPO, Zynga has lost 70% of its value. Worse still, some of its top executives and managerial talent are jumping ship” (Farivar, 2012). Groupon, another high flying startup, started losing talent as its stock fell by half or more in 2012 (Agrawal, 2012).

Another example of the positive impact of a high valuation is Facebook. A Russian Investment firm, Digital Sky Technologies (DST), invested an initial \$200M in the firm at a valuation of \$10B in May of 2009. In 2011 there was an additional financing round in which DST invested another \$50M, along with a \$450M investment by Goldman Sacs, at a \$50B valuation, implying a 5-fold increase (Craig and Sorkin, 2011, Olson, 2011). It is suggested by Olson (2011) that Goldman’s investment would not have occurred without the continuing involvement of DST. Johnson (2012) argues that DST’s strategy “seems to boil down to a series of straightforward steps: first find a category leader like Facebook, Zynga or Groupon; then use heavy investment to make sure that they outpace their competition and stretch their lead even further; then continue pushing them, with more money if necessary, towards an IPO.”

1.2. Related Literature. As noted above, Admati and Pfleiderer (1994) argue that despite its potential advantages, stage financing might also create inefficiencies because of the venture capitalist’s increased bargaining power at later stages. In their model, this problem is solved by having the VC commit ex ante to invest via a “fixed-fraction” contract, whereby it receives a fixed fraction of the payoff and also funds the exact same fraction of investment at each stage. They rely on the fact that courts will be able to enforce this contract because of its simplicity (the fixed fraction does not vary with the state). They show that this simplicity together with the ability to place an ex ante bond by the VC makes their contract effectively renegotiation proof. However, observationally, VCs do not appear to invest in equal proportions in each round of financing. This could be because of the unpredictable nature of a startup’s capital requirements and the difficulty of ensuring ex ante that sufficient outside investors can be attracted in the future, or that the VC will have sufficient funds to maintain its proportional investment. As a result, stage financing contracts are likely to be more complex and enforceability through courts more difficult and costly. Our contract, on the other hand, has the attraction that commitment arises naturally through the need for posturing, and there is no need to rely on enforcement through the courts.

Two existing empirical papers address the question of whether and to what extent VCs seem to take advantage of their bargaining power vis a vis entrepreneurs in later rounds. Atanasov, Ivanov, and Litvak (2012), study this by looking at incidences of lawsuits against VCs. Broughman and Fried, 2012, look at the pricing of late stage rounds for a sample of Silicon Valley startups that exit via M&A. The latter paper finds evidence that VCs do not tend to take advantage of entrepreneurs even in situations where it seems most likely they would be able to do so. In fact, they find that the pricing is relatively high in these situations. While the two papers both conclude that there are forces limiting the ability or desire of VCs to take advantage of entrepreneurs, they do not explicitly test whether

third party perceptions are a potential explanation. However, Broughman and Fried (2012) do mention the possibility that VCs may want to “window dress” to facilitate future fund raising and to avoid demoralizing employees with low valuations. While we would argue that our posturing mechanism is consistent with their results, their existing tests do not provide any way to differentiate between our explanation and other possible factors limiting ex post opportunism. We believe our results should motivate future broad-based empirical studies concerned with the effect of posturing on VC round pricing in particular, and for multi-stage hold up problems in general.

Outside the VC setting, Aghion and Tirole (1994) provide a seminal analysis of the financing and control of innovative activities in an incomplete contracting framework. In their setting, a strategic investor both funds research and is the final user of the innovation. They show that the optimal allocation of property rights gives ownership to the party whose effort is more beneficial. Fulghieri and Sevilir (2009a) consider the optimality of different organizational and financial arrangements for an investor and research unit when there is a competing pair of firms.⁹ In both of these papers, initial ownership stakes are irrelevant, as there is complete renegotiation ex post. In our setting, by contrast, the initial stake plays two important roles. First, it sets the entrepreneur’s walk-away payoff in the event the project has an early exit, and thus can be calibrated to ensure optimal effort. Second, a larger stake for the VC makes it more difficult to posture (since its benefit from good third party decisions rises), leading to higher late stage prices. The staged financing model of Inderst, Mueller, and Munnich (2007) shares the former feature. Like in our model, they assume viable startups can generate a positive return even if not refinanced, so the initial stake sets a threat point for the renegotiation. Their model also admits the possibility of reduced entrepreneurial effort

⁹Fulghieri and Sevilir (2009b) also study the problem of commitment when a VC may extract surplus ex post and weaken ex ante incentives, but the mechanism they consider is very different, namely a decrease in the size of the VC’s portfolio of investments.

due to high ex post VC bargaining power. However, in their setting the solution to this lack of incentives is to force the startups to compete for scarce funds at the second stage.

Neher (1999) shows that staged financing can be efficient when the entrepreneur has the power to bargain away the VC's claim once the investment is sunk. Repullo and Suarez (1999), Schmidt (2003), and Bergemann and Hege (1997) focus on the effect of security design on the entrepreneur's and/or VC's effort incentives. Marx (1998) studies how security design affects liquidation decisions, while Cornelli and Yosha (2003) show that convertible securities can reduce "window dressing" by entrepreneurs. Axelson (2007) studies security design in a one period model when, like here, the investor has private information rather than the issuer. None of these papers consider how the contracts or pricing might be viewed by third parties.

Liu (2012) studies a setting in which takeover bids convey information to third party investors about the bidder's valuation, which can then affect future financing terms. The mechanism is very different from ours. For example, in our setting, overpricing only occurs when the VC has an existing stake in the firm, as the gain on its position gives it the necessary incentives to posture at higher prices. In Liu (2012), overbidding can occur without existing stakes because bidders may receive a benefit of overpricing in a subsequent security issue.

Our analysis also shares some elements with models of signaling to two audiences, in particular Gertner, Gibbons, and Scharfstein (1988), in which financial structure signals information about market demand (and hence firm value) to both financial markets and product market competitors. Our analysis differs in that we study a two-stage financial market interaction and show that the need to signal to third parties disciplines the second financing stage, so that the overall financial market equilibrium is more efficient. Our paper is also related to papers that relate overbidding behavior in takeovers to initial stake ownership. For example, Burkart (1995) and Singh (1998) show that bidders with toeholds are likely to

overbid in equilibrium. Mathews (2007) shows that this fact can be exploited by a potential target and potential bidder to extract surplus from other bidders ex ante. In these papers the overbidding incentive comes from a desire to increase the sale price of their initial stake if they are a losing bidder, and is not related to the need to signal to outsiders.

2. THE MODEL - BASIC FRAMEWORK

Consider a start-up firm owned by a wealth constrained entrepreneur (E) that needs financing over two stages. An initial investment of I_1 is needed at time zero to perform research and development for a new product. Conditional on development of a viable product, the owners of the firm can choose a safe “early exit” at time 2, which we refer to as a sale to a strategic buyer (i.e., an M&A exit involving an existing firm in a related market), or can take a risky bet on a “late exit” strategy that pays off at time 3, which we refer to as an IPO.¹⁰ The late exit strategy requires an additional investment of I_2 at time 2. We assume any capital above I_1 at time zero would be wasted by the entrepreneur, so stage financing is strictly optimal. Ex ante, there is a competitive venture capital market with multiple identical potential financiers.

Following the investment of I_1 at time zero, the development of a viable product depends on effort undertaken by E at time 1. For convenience we assume E 's chosen effort level e corresponds to the probability of the product becoming viable. Choosing an effort level e costs the entrepreneur $c(e)$, where $c'(\cdot) > 0$ and $c''(\cdot) > 0$.

At time 2, if the product turns out to be non-viable the initial investment of I_1 is recoverable via liquidation, but there is no additional value in the firm.¹¹ If the product turns out to be viable, then the firm is worth $\pi_1 > I_1$ if sold to a strategic buyer at time 2. The value π_1

¹⁰We use these different exit labels solely for expositional convenience. The structure and timing of payoffs is all that matters for the results.

¹¹See the text following Proposition 4 for further discussion of the implications of this assumption.

corresponds to the maximum price a strategic buyer will pay given their preferred use of a viable product (which may be a different, and, in particular, less risky use than in an IPO attempt). If, instead, the firm remains independent and raises an additional investment of I_2 from its current venture capitalist (hereafter the “VC”), then firm value, realized at time 3, will be either $\pi_2 > \pi_1$ (from a successful IPO strategy) or zero (i.e., choosing to pursue the risky late exit option results in either greater success or complete failure).¹²

The ability to successfully exit late via IPO and realize π_2 at time 3 depends on both the final state of nature and the beliefs of third parties. The state of nature is $\Theta \in \{G, B\}$, and the random variable s , which is continuously distributed over $[0, 1]$, gives the probability that the state is good. The realization of s is observed by the VC just before time 2. The good state of nature represents an outcome where the firm and its product are of sufficiently high quality to complete a successful IPO. Third parties form beliefs about s just after Time 2. If they are convinced that s is sufficiently high at that time (defined below) *and* the state ultimately turns out to be good, G , then the firm successfully exits via an IPO at time 3 and returns π_2 . If *either* the third parties are not convinced *or* the state turns out to be bad, B , then the firm ultimately fails and the payoff is zero.

We assume that third party beliefs about s are sufficiently strong to support an IPO attempt if they perceive that the probability of the good state is at least $q > E[s]$. We purposefully choose this reduced form characterization of third party beliefs and actions because we believe the basic model will apply to a wide range of scenarios (as discussed in

¹²The assumption that the firm has to raise the second stage funding from its initial VC is motivated by the informational advantage that this VC acquires as a result of its close relationship with the firm. I.e., as discussed in the introduction, the firm would face a lemons problem if it were to approach another VC for second round funding.

the Introduction) in which different types of third parties may take actions that affect firm value after forming beliefs about the firm's quality.¹³

For convenience, we define \hat{s} as the signal that satisfies $E[s|s > \hat{s}] = q$, i.e., it is the minimum s such that if third parties infer only that $s > \hat{s}$, their beliefs will be sufficiently strong for a late exit attempt to succeed. Throughout we assume that \hat{s} is higher than the cutoff level of s at which risking an IPO is positive NPV, i.e. $\hat{s} > \underline{s}$ where:

$$\underline{s}\pi_2 - I_2 = \pi_1 \implies \underline{s} = \frac{I_2 + \pi_1}{\pi_2}. \quad (1)$$

Figure 1 illustrates the timeline of the game. Branches with dashed lines indicate random events chosen by nature, while those with solid lines are decisions by players in the game. Bold italics indicate final firm payoffs in different outcomes. To summarize, first an initial investment of I_1 is made. Next, E chooses his effort level e and nature determines whether the product is viable. Given viability, a late or early exit is chosen. If a late exit is chosen, I_2 must be invested. The third party beliefs are then formed (and are either sufficiently strong, Y, or not, N), and the IPO is successful with probability s at time 3.

¹³Many third parties discussed in the introduction, such as current or future employees, customers and investors, are clearly more likely to take actions that increase firm value when they believe the firm or its market are of high quality. Using posturing to discourage a (potential) competitor is more subtle, as signaling a high value could, in some circumstances, encourage competitor entry (e.g., because it indicates a large market size). However, we believe our model will apply in any situation where the strength of the firm-specific component of the signal (i.e, the quality of the firm's products and its ability to dominate the market) outweighs the market-wide component (i.e., this is a very large/profitable market). See Appendix 1 for such an example.

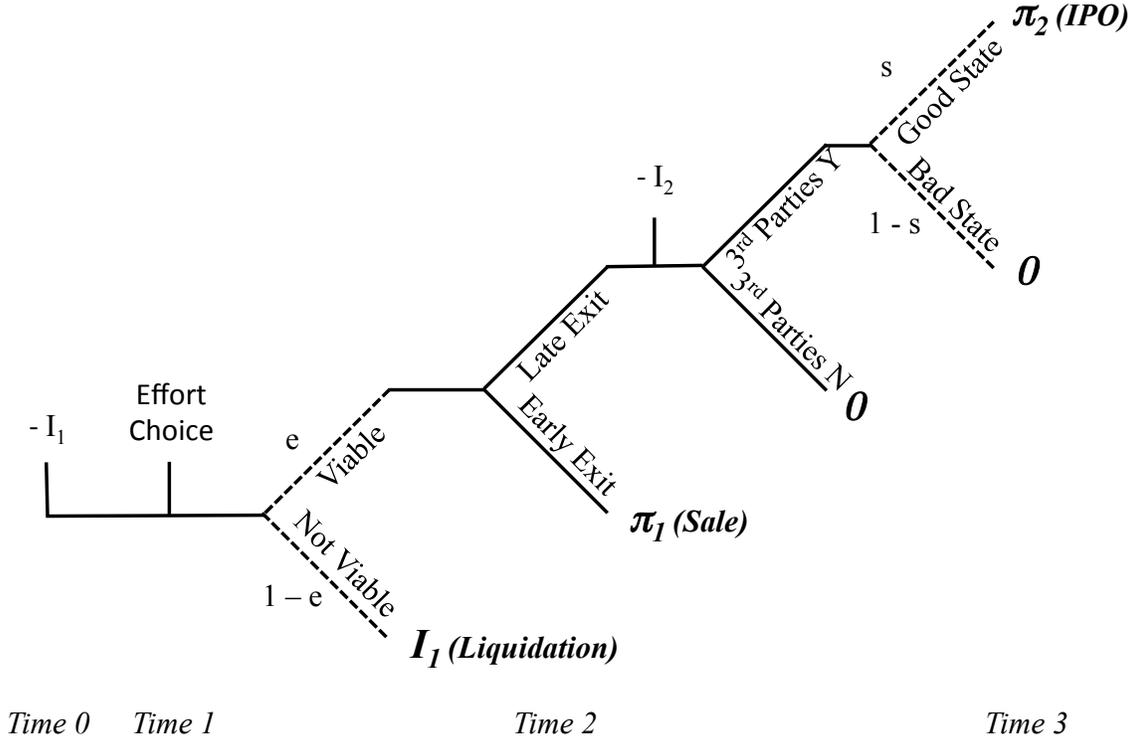


FIGURE 1. Timeline of the Base Model

3. BENCHMARK MODELS

In this section we consider two benchmark models built on the basic framework above. Understanding these models helps to illustrate the unique features of the contracting environment in our main posturing model, which we specify and solve in Section 4.

3.1. Complete Contracting Model. We first consider a version of the model in which, in addition to the VC's private observation of s just before time 2, some public information about both the state *and* product viability are observable and verifiable at time 2. In particular, we assume that all parties observe a verifiable signal $S \in \{H, L\}$ at time 2, where $S = H$ if $s \geq \hat{s}$ and $S = L$ if $s < \hat{s}$, and can also observe and verify the viability of the product. Thus, third party beliefs are sufficiently strong for a late exit attempt as long as $S = H$.

Since the VC market is ex ante competitive, we assume E has all of the bargaining power and makes a take-it-or-leave-it offer to a chosen VC for a funding contract at time zero. E will optimally design a contract that maximizes overall surplus if possible. Such a contract can potentially include a non-negative side payment (hereafter τ) from the VC to E at time zero. Given this, E will seek to ensure that the firm is optimally liquidated if non-viable, sold to the strategic buyer if viable but $S = L$, or further funded at time 2 if viable and $S = H$. In addition, the contract should ensure that E will exert the first best level of effort, which solves

$$\begin{aligned} \text{Max}_e \quad & e(Pr[s \geq \hat{s}](E[s|s \geq \hat{s}]\pi_2 - I_2) + Pr[s < \hat{s}]\pi_1) + (1 - e)I_1 - I_1 - c(e), \quad (2) \\ \text{s.t.} \quad & e \in [0, 1], \end{aligned}$$

and has first order condition

$$c'(e) = Pr[s \geq \hat{s}](E[s|s \geq \hat{s}]\pi_2 - I_2) + Pr[s < \hat{s}]\pi_1 - I_1, \quad (3)$$

where the second order condition is clearly satisfied given $c''(\cdot) > 0$.

Consider a contract that specifies liquidation given non-viability, an early exit/sale given viability when $S = L$, and a capital injection of I_2 from the VC and an IPO attempt given viability and $S = H$. To fully specify the contract it simply remains to allocate the possible payoffs, I_1 , π_1 , and π_2 . To be optimal and feasible the allocation must satisfy the VC's participation constraint, and calibrate E 's effort to match the first best. It is clear that giving the VC a liquidation preference when the product is not viable will encourage effort, so we assume from here forward that the VC recovers the full payoff I_1 upon liquidation.¹⁴

¹⁴This assumption is without loss of generality as it never constrains the parties away from achieving the maximum attainable efficiency. This is because it turns out that encouraging effort provision by the entrepreneur is always the binding constraint on efficiency when the first best cannot be achieved.

We assume that the contract allocates to the VC a proportion α_1 of the early exit/sale payoff π_1 . To be consistent with the way VC contracts are implemented in practice, we assume that the VC's total stake in the IPO payoff π_2 is ultimately

$$\alpha_1(1 - \alpha_2) + \alpha_2 \equiv \alpha, \quad (4)$$

where α_1 is the equity “purchased” by the VC at the first stage, and α_2 is the additional equity “purchased” at time 2 when I_2 is infused, which dilutes α_1 . This along with the VC's recovery of I_1 upon liquidation corresponds closely to real-life VC contracts, which in early rounds often consist of a redeemable convertible preferred security giving a high fixed payoff to the VC in the event of failure, and conversion into a standard equity claim in case of success (see, e.g., Sahlman (1990) and Kaplan and Stromberg (2003)). Note that the assumption of this contracting structure is without loss of generality since any arbitrary sharing rule conditioned on the different possible surplus realizations can be expressed in this form.

Given this, E 's effort choice problem will be

$$\text{Max}_e e(Pr[s < \hat{s}](1 - \alpha_1)\pi_1 + Pr[s \geq \hat{s}](1 - \alpha)E[s|s \geq \hat{s}]\pi_2) - c(e) \quad (5)$$

$$s.t. e \in [0, 1].$$

The first-order condition is then

$$c'(e) = Pr[s < \hat{s}](1 - \alpha_1)\pi_1 + Pr[s \geq \hat{s}](1 - \alpha)E[s|s \geq \hat{s}]\pi_2, \quad (6)$$

and the second order condition is clearly satisfied given $c''(\cdot) > 0$.

We have the following result (all proofs can be found in Appendix 2).

Proposition 1. As long as the initial startup investment is profitable, there exists a continuum of pairs (α_1, α_2) that yield an optimal contract, where each such pair sets the right hand side

of (6) equal to the right hand side of (3). Under such a contract, the first best is achieved and the VC's participation constraint is satisfied with a transfer from the VC to E of $\tau = 0$.

Because the parties can contract on both viability and a high enough public signal to make an IPO exit possible, they are able to achieve the first best with a complete contingent contract. The following sections explore the outcome when such a contract is infeasible due to contractual incompleteness.

3.2. Hold Up Model. Here we consider a variation of the above model in which the public signal S and product viability are no longer verifiable so that contracts cannot be written based on their realizations. We assume S is still observable to all parties, but product viability is observable only to E , the VC, and the strategic buyer.¹⁵ To illustrate the maximum potential for inefficiency, we assume that at time 2, the VC has all of the bargaining power and can make a take it or leave it offer to E for additional funding of I_2 (though E retains the bargaining power at time zero). Thus, even when the public signal is high and attempting an IPO is profitable, the VC will take advantage of his bargaining power by forcing E down to his walkaway payoff. The shift in bargaining power from E to the VC over time reflects the fact that the VC's continued participation is crucial to raising additional funds to attempt an IPO, while the entrepreneur's contribution to firm value is lessened after his effort is exerted.¹⁶

¹⁵Viability is made unobservable to outsiders here simply to support our assumption that E cannot approach an alternative VC at time 2. Given that venture financing is usually targeted at start-ups with new technologies/products, viability is likely inferable only by those with intimate knowledge of the technology/product.

¹⁶The complete shift in bargaining power makes the results as clear as possible, but such an extreme shift is not necessary for our results. As long as the VC gains sufficient advantage, the hold up problem remains relevant as do our comparisons to the Posturing model below.

The time zero contract offered by E to the VC will now take into account the expectation that this sub game will occur when the product is viable and the public signal is high ($S = H$). We keep the same contracting framework as above (without loss of generality), with a time zero contract including a liquidation preference for the VC when the product is not viable (which will help maximize E 's effort), a first round equity stake of α_1 conditional on viability, and a second round stake of α_2 if an IPO is to be attempted. Now, though, the initial contract can only credibly specify α_1 since α_2 will be determined in the time 2 renegotiation (if the contract did specify an α_2 , it would be meaningless as it would optimally be ignored by the VC in its renegotiation offer).

As a result of the contractual incompleteness, it is also important for the initial contract to specify control rights. That is, it should indicate which party has the right to decide whether the firm should be liquidated or sold in case the parties do not agree on terms to fund a late exit/IPO strategy. We assume these rights are assigned to E . This assumption is innocuous as long as E has the correct incentive to sell rather than liquidate the firm at time 2 when the project is viable but there is no agreement for additional funding.

The concern with hold up is that it might result in too little entrepreneurial effort since E 's share of π_2 is constrained by the time 2 renegotiation. Indeed, if the product is viable and $S = H$, the VC will offer a second stage stake such that E 's continuation payoff equals his walkaway payoff, or

$$(1 - \alpha)E[s|s \geq \hat{s}]\pi_2 = (1 - \alpha_1)\pi_1. \quad (7)$$

Replacing α with its definition from (4) and solving for the second round stake, α_2 , gives

$$\alpha_2 = 1 - \frac{\pi_1}{E[s|s \geq \hat{s}]\pi_2} \equiv \alpha_2^H. \quad (8)$$

Note that the third parties can infer product viability from the fact that E and the VC have agreed to attempt a late exit, so this together with $S = H$ is sufficient to ensure desired third party actions. Also note that even though the VC has superior information about s , it cannot use that information to its advantage because, given $S = H$, any attempt to reveal a high s and demand a stake larger than α_2^H will be mimicked by lower types.

Since α_2^H does not depend on α_1 , it is clear that if this renegotiation reduces E 's effort below the first best for a given α_1 , a reduction in α_1 (and thus a higher payoff if the early exit option is actually implemented) is the only way to increase E 's effort. The hold up problem will reduce efficiency only when this is no longer feasible, i.e., when a first round stake for the VC of less than zero would be required to achieve an efficient effort choice. In other words, the best that can be done is to ensure E a payoff of π_1 if the project is viable and no payoff if it is not. Hold up will thus decrease efficiency whenever π_1 is less than the right hand side of (3), the first order condition for the first best effort, i.e., if

$$\begin{aligned} \pi_1 &< Pr[s \geq \hat{s}](E[s|s \geq \hat{s}]\pi_2 - I_2) + Pr[s < \hat{s}]\pi_1 - I_1 & (9) \\ \implies \pi_1 &< E[s|s \geq \hat{s}]\pi_2 - I_2 - \frac{I_1}{Pr[s \geq \hat{s}]} \end{aligned}$$

When this inequality does not hold, efficient effort can be elicited with a non-negative α_1 , so the Hold Up model simply pins down the equilibrium equity stakes to a particular pair from among those that are optimal in the Complete Contracting model. In particular, since α_2^H is given by the renegotiation game, α_1 will be set to elicit optimal effort by setting the right hand side of (3) equal to the right hand side of (6) but with $\alpha = \alpha_1^H(1 - \alpha_2^H) + \alpha_2^H$ as follows

$$\begin{aligned} Pr[s < \hat{s}](1 - \alpha_1^H)\pi_1 + Pr[s \geq \hat{s}](1 - \alpha_1^H(1 - \alpha_2^H) - \alpha_2^H)E[s|s \geq \hat{s}]\pi_2 & \quad (10) \\ = Pr[s \geq \hat{s}](E[s|s \geq \hat{s}]\pi_2 - I_2) + Pr[s < \hat{s}]\pi_1 - I_1 & \end{aligned}$$

$$\implies \alpha_1^H = \frac{I_1 + Pr[s \geq \hat{s}](I_2 + \pi_1 - E[s|s \geq \hat{s}]\pi_2)}{\pi_1} \quad (11)$$

We have the following result.

Proposition 2. (a) When $\pi_1 < E[s|s \geq \hat{s}]\pi_2 - I_2 - \frac{I_1}{Pr[s \geq \hat{s}]}$, full efficiency cannot be achieved in the Hold Up model because there will be too little entrepreneurial effort. In this case, whenever it is profitable for E to seek funding, he offers (and the VC accepts) a stake of $\alpha_1 = 0$ in the initial contract at time 0, and τ , the up front transfer from the VC to E , is positive. At time 2, the VC offers (and E accepts) a stake of $\alpha_2 = \alpha_2^H$ if the product is viable and $S = H$.

(b) When $\pi_1 \geq E[s|s \geq \hat{s}]\pi_2 - I_2 - \frac{I_1}{Pr[s \geq \hat{s}]}$, full efficiency is achieved in the Hold Up model. In this case, whenever it is profitable for E to seek funding he offers (and the VC accepts) a stake of $\alpha_1 = \alpha_1^H$ in the initial contract at time 0, and the up front transfer is $\tau = 0$. At time 2, the VC offers (and E accepts) a stake of $\alpha_2 = \alpha_2^H$ if the product is viable and $S = H$.

Thus, we see that hold up causes inefficiency when the early exit payoff is relatively low, as the entrepreneur's share of this payoff is the source of his incentives given the onerous renegotiation game. In these cases, the VC will take its liquidation preference if the project ends up non-viable but no additional payoff given an early exit. Instead, its upside comes solely from the late exit possibility, where it is able to exploit its renegotiation power.

4. POSTURING MODEL

We now turn to our full Posturing model. Here we modify the Hold Up model by assuming that there is no longer a public signal S . Instead, the only information about the state is the VC's private observation of s just before time 2. This puts the onus on the VC to convince the third parties by signaling that s is sufficiently high. We assume that the only way to credibly signal s is through the terms of the time 2 funding contract. We continue to assume

that E makes a take it or leave it offer to a chosen VC at time zero, while at time 2, it is the VC who makes a take-it-or-leave-it offer to the entrepreneur for a new contract for funding of I_2 . Notice that we thus maintain the assumption of a shift in bargaining power from E to the VC over time. Later we also consider what would happen if the bargaining power remained with E .

We derive a pure strategy Perfect Bayesian equilibrium (PBE) using backward induction. We begin with the time 2 bargaining game between E and the VC. We maintain the same assumptions as in the Hold Up model about the form of the contracts and the control rights allocation.

4.1. The Second Stage Negotiation. Consider the problem at time 2 conditional on the discovery of a viable product (if the product is not viable, the entrepreneur optimally liquidates the project and the final payoff I_1 is simply distributed to the VC). The VC has privately observed s and can make a take-it-or-leave-it offer to provide funding of I_2 in exchange for an incremental equity stake α_2 , leading to a final share of firm value for the VC equal to $\alpha \equiv \alpha_1(1 - \alpha_2) + \alpha_2$. Subsequently, the third parties will form their beliefs.

As the financing terms (in particular α_1 and α_2) are the only conditioning information available to the third parties, the VC will take into account how the contract terms affect their beliefs. In particular, whenever the VC prefers to fund the firm instead of letting it be sold to the strategic buyer, it would like to generate sufficient “excitement” about the firm through a high issue price to encourage desirable third party actions. In other words, the VC will take into account the feedback loop created by third party beliefs, in that their resulting actions increase firm value and justify the high prices ex post. However, anytime the VC believes the third party beliefs will not be sufficiently strong, or that additional funding is negative NPV, its optimal strategy is to simply let the firm be sold in an early exit for π_1 .

One possible type of equilibrium is one in which the VC always lets the firm be sold in an early exit (or, equivalently, makes an offer it knows will be refused with probability one). One might think such an equilibrium could be prevented by a deviation by the VC to a smaller stake when s is sufficiently high, but this can be ruled out by specifying out-of-equilibrium beliefs that any stake offer must come from a VC with a low s . Thus, such an equilibrium always exists.

However, there are other equilibria that can generate significantly greater surplus by having the VC sometimes offer a stake that convinces the third parties that the signal is high enough. In particular, we characterize equilibria where, conditional on a viable product, the VC can be in one of two “pools” depending on s . One pool refuses to make an offer (which triggers an immediate sale), while the other offers a stake, defined as α_2^P , following which the third party beliefs are sufficiently strong. Clearly, if a VC with a given signal finds it optimal to buy a stake of α_2^P in order to convince third parties, then with a higher signal it will also find it optimal to do so (it will be more profitable the higher is s). Thus, the equilibrium must have a “threshold” structure such that there is a cutoff signal, say s^* , such that all types above s^* offer a stake α_2^P and convince the third parties, while all types below s^* forego the possibility of an IPO. The critical level that separates the two pools depends, in part, on the level of \hat{s} , i.e., how hard it is to convince the third parties.¹⁷

Any equilibrium in which the third parties are sometimes convinced must be a threshold equilibrium, i.e, it can have at most one equity stake size offered by all types of VCs for which the offer will be accepted (where the VC’s “type” refers to its signal, s). To see this, first consider a proposed equilibrium in which there are multiple stake sizes that lead to sufficiently strong beliefs for the third parties. In such a case the types who are supposed

¹⁷E’s acceptance of the offer is, obviously, also required, but, as will be shown below, E’s participation constraint will not bind, i.e., E will always accept whenever the third parties’ beliefs are sufficiently strong.

to offer the smaller stake will optimally deviate to the largest stake (the third parties will remain convinced, and the VC will get a higher proportion of the payoff), so this cannot be an equilibrium. Therefore, all equilibria are either threshold equilibria, or have the firm always sold in an early exit.

To derive a threshold equilibrium, the next question is how to determine the critical level s^* and the offered stake α_2^P . For a given level of s^* , the offered stake α_2^P must be such that a VC of type s^* is just indifferent to offering the stake or not, so that all higher types strictly prefer this stake (if it convinces the third parties), while all lower types strictly prefer an immediate sale to the strategic buyer (this is what is required to convince the third parties that $s \geq s^*$). The indifference condition that defines α_2^P as a function of s^* can therefore be expressed as

$$(\alpha_1(1 - \alpha_2^P) + \alpha_2^P)s^*\pi_2 - I_2 = \alpha_1\pi_1 \quad (12)$$

$$\implies \alpha_2^P = \frac{I_2 - \alpha_1(s^*\pi_2 - \pi_1)}{(1 - \alpha_1)s^*\pi_2}. \quad (13)$$

This equity stake is easily shown to be increasing in I_2 and π_1 , and decreasing in s^* , α_1 , and π_2 . It is also straightforward to show that $\alpha_2^P < \alpha_2^H$ always holds.¹⁸

Since the VC is indifferent to this offer at $s = s^*$, it must be leaving significant money on the table at higher signals, which implies that the entrepreneur is receiving a significant share of the surplus despite his lack of bargaining power. In particular, he does better in expectation than his walkaway payoff of $(1 - \alpha_1)\pi_1$, which is his continuation payoff in this state in the Hold Up model. The price of the second stage investment can be expressed as

¹⁸To see this, first note that (13) is decreasing in α_1 and s^* and equals $\frac{I_2}{\hat{s}\pi_2}$ when $\alpha_1 = 0$ and $s^* = \hat{s}$. Now note from (8) that α_2^H can be expressed as $\frac{E[s|s \geq \hat{s}]\pi_2 - \pi_1}{E[s|s \geq \hat{s}]\pi_2}$. Replacing $E[s|s \geq \hat{s}]$ with \hat{s} would yield $\frac{\hat{s}\pi_2 - \pi_1}{\hat{s}\pi_2}$ which is clearly greater than $\frac{I_2}{\hat{s}\pi_2}$. Finally notice that $\frac{E[s|s \geq \hat{s}]\pi_2 - \pi_1}{E[s|s \geq \hat{s}]\pi_2} > \frac{\hat{s}\pi_2 - \pi_1}{\hat{s}\pi_2}$ since the latter expression is clearly increasing in \hat{s} .

$\frac{I_2}{\alpha_2}$, so the fact that E has a higher continuation payoff (lower α_2) implies higher pricing here than in the Hold Up model. This is the sense in which the VC uses higher pricing (i.e., a lower stake for a given investment I_2) to generate excitement and convince the third parties, which significantly benefits the entrepreneur. Essentially, the need to posture causes the VC to bargain less forcefully, leading to a higher pre-money value and a higher payoff to E .

In fact, the need for posturing often eliminates any benefit to the VC from having the bargaining power at time 2. To see this, consider how the model would change if E were to hold the bargaining power at this stage. In this case, holding s^* constant, E would offer an equity stake intended to cause the VC to accept only if $s \geq s^*$ (i.e., a screening contract), and otherwise let the firm be sold. But the condition that determines the equity stake that would accomplish this is exactly (13), so the stake would be the same. Thus, whenever E would optimally choose to have all VC types with $s \geq s^*$ participate, the need to posture essentially puts the bargaining power back in E 's hands. To put it another way, the formal allocation of bargaining power at this stage is then irrelevant because of the need to posture.¹⁹

In contrast, however, the allocation of bargaining power always affects the Hold Up equilibrium. If the bargaining power remained entirely with E at stage 2 in the Hold Up model, then he would optimally offer a stake of $\alpha_2 = \alpha_2^P$ when $S = H$ as long as \hat{s} is sufficiently high.²⁰ Thus, while for convenience we assume the bargaining power shifts entirely to the VC

¹⁹It is not always the case that E would want to choose the same s^* as in the equilibrium we focus on below, where $s^* = \hat{s}$. He would sometimes choose a higher s^* when \hat{s} is low in order to capture a greater part of the VC's private information rent. In such cases, the shift in bargaining power to the VC does benefit the VC somewhat. However, our statement that the allocation of bargaining power is irrelevant will hold whenever \hat{s} is sufficiently high.

²⁰As noted in footnote 18, when \hat{s} is not sufficiently high and E has the bargaining power, he will sometimes prefer to offer a stake lower than α_2^P and screen out more of the lower VC types, with or without posturing.

at time 2, all that is needed for our results is that the VC gain sufficient bargaining advantage so that $\alpha_2^H > \alpha_2^P$.

We have not yet pinned down a unique equilibrium of the time 2 subgame since we have not defined a unique s^* . In fact, there are a continuum of subgame equilibria as described above, where any $s > \hat{s}$ can serve as s^* . In other words, we have the following result.

Proposition 3. Conditional on a viable product, there exist a continuum of threshold-type subgame equilibria for the time 2 negotiation, with each equilibrium indexed by a critical signal, $s^* \in [\hat{s}, 1]$. In each equilibrium, the VC declines to make an offer for all $s < s^*$, and demands a stake of $\alpha_2^P < \alpha_2^H$ in exchange for funding of I_2 for all $s \geq s^*$. Furthermore, third parties believe that $s \geq s^*$ (and E accepts) anytime a stake of α_2^P is offered, and otherwise the firm is sold in an early exit. Expected firm value (from the VC's perspective) is π_1 for all $s < s^*$ and $s\pi_2$ for all $s \geq s^*$.

There are multiple equilibria in this signaling game because lower types always balk at paying too high of a price to mimic higher types. Thus, there is always a system of beliefs that is consistent with any “minimum” price required to believe the VC is in the higher pool that is expected to attempt an IPO. Such a minimum price is supported by out of equilibrium beliefs that any VC offering lower than the minimum price must be a low type. It is interesting to note here the difference between our signaling model and traditional models such as Leland and Pyle (1977, “LP”), where the owner signals a high value by retaining a large portion of the firm. The reason for the difference is that in our setting the signaler is a buyer of equity, while in LP the signaler is a seller of equity. Thus, while in LP lower types will not mimic high types because retaining a large amount of low value equity is expensive despite getting a higher price for the sold equity, here the lower types will not mimic because paying too high of a price for new equity is negative NPV given low fundamentals despite the positive signal that convinces the third parties.

From here on we focus on the ex ante efficient sub game equilibrium, which sets $s^* = \hat{s}$ and thereby maximizes firm NPV. This also coincides with the most profitable sub game equilibrium for the VC conditional on any $s > \underline{s}$. This equilibrium is a pareto optimum, and the unique pareto optimum when \hat{s} is sufficiently high. Furthermore, selecting this equilibrium makes the results in this section directly comparable to those of the benchmark models in the previous section. If we chose any other threshold equilibrium with a higher s^* , our pricing and bargaining results would be amplified, but the efficiency benefits of posturing would be muted (since profitable IPO attempts would sometimes be passed up).

4.2. The First Stage Negotiation. As above, the optimal time zero contract offered by E will set α_1 to elicit first best effort if possible. Intuitively, α_1 should be larger in the Posturing model than in the Hold Up model since α_2 is smaller. Indeed, whereas in the Hold Up model the optimal α_1 is often zero, in the Posturing model a positive α_1 is often required to ensure that there is not over-provision of effort, since E now captures much more of the surplus from the late exit strategy. Setting the right hand side of (6) equal to the right hand side of (3), replacing α with $\alpha_1(1 - \alpha_2^P) + \alpha_2^P$, and solving for α_1 gives

$$\alpha_1 = \frac{\hat{s}I_1 + Pr[s \geq \hat{s}]I_2(\hat{s} - E[s|s \geq \hat{s}])}{\pi_1(\hat{s}Pr[s < \hat{s}] + E[s|s \geq \hat{s}]Pr[s \geq \hat{s}])} \equiv \alpha_1^P. \quad (14)$$

We have the following result.

Proposition 4. In the unique equilibrium of the time zero bargaining game, whenever $\alpha_1^P \geq 0$ and it is profitable for E to seek funding, E offers a contract to the VC which gives it an equity stake of size $\alpha_1 = \alpha_1^P > \alpha_1^H$ in return for funding of I_1 , and the first best is achieved. In this case the monetary transfer from the VC to E is $\tau = 0$. When $\alpha_1^P < 0$ and it is positive NPV for E to seek funding, E offers a contract to the VC which gives it an equity stake of

size $\alpha_1 = 0$ in return for funding of I_1 , and there is less than first best effort by E . In this case, the monetary transfer τ from the VC to E is positive.

Since the VC takes less advantage of its bargaining power in the Posturing model, it extracts less surplus from the entrepreneur ex post, which implies that its initial stake, α_1^P , can be larger and still provide E with sufficient incentives to provide optimal effort. Since α_2^P is decreasing in α_1 , this implies that once the optimal level of α_1 is factored in, α_2^P is even smaller relative to α_2^H .

As before, τ is equal to zero in equilibrium when full efficiency is achieved because of our assumption that the firm simply returns the initial investment of I_1 when the product is not viable. Changing this assumption such that the payoff in that state exceeds I_1 would simply shift the optimal τ upward without qualitatively changing any of the other results (clearly, α_1^P and α_2^P will also change incrementally, but the nature of the equilibrium is the same). However, assuming a smaller payoff than I_1 in this state would imply $\tau < 0$ (i.e., E pays the VC up front), which is not possible because of the entrepreneur's wealth constraint. This would induce additional inefficiency in the equilibrium. We do not analyze this case here so that we can more easily focus on the contrast between the posturing and hold up equilibria.

4.3. Efficiency Implications. An important consequence of the shift in bargaining power back toward E is that the posturing equilibrium will often be more efficient. In fact, we have the following efficiency result.

Proposition 5. Whenever the equilibrium in the Hold Up model is inefficient, i.e., $\pi_1 < E[s|s \geq \hat{s}]\pi_2 - I_2 - \frac{I_1}{Pr[s \geq \hat{s}]}$, efficiency is greater in the Posturing model than in the Hold Up model. Furthermore, it is optimal to fund the firm more often in the Posturing model. Whenever the equilibrium in the Hold Up model is efficient, firm value is the same across the two models.

This result shows that the need to posture can actually increase firm value by eliciting greater effort from E and thus enabling a more efficient ex ante contract. This occurs because the need for posturing allows the VC to commit not to expropriate E 's rents in the continuation stage. Thus, E realizes that even though bargaining power passes to the VC in later rounds, the VC is limited in exploiting it. Posturing therefore makes it more likely that the entrepreneur is willing to enter into a staged financing contract.

5. EMPIRICAL IMPLICATIONS

In this section we explore the empirical implications of our model. First consider in greater detail how the second round equity purchase is priced in the Posturing versus the Hold Up equilibria. As noted above, the implied price per share of the purchase can be expressed as $\frac{I_2}{\alpha_2}$. First consider $\alpha_2 = \alpha_2^P$, i.e., the Posturing model. If $\alpha_1 = 0$, the price reduces to $\frac{I_2}{\alpha_2^P} = \hat{s}\pi_2$, which is equal to expected firm value per share conditional on $s = \hat{s}$. If the VC has no existing stake, it is willing to pay no more than expected firm value for the stock. From above, the stock must be priced such that the VC with the lowest signal in the pool, \hat{s} , is just indifferent over the purchase. Thus, the price must reflect expected firm value from the perspective of the VC given that signal. However, since this price holds for the entire pool of signals $s \geq \hat{s}$, the equity that is sold will be underpriced on average.

Turning to the Hold Up model, given the result that $\alpha_2^H > \alpha_2^P$, underpricing will be greater. This is intuitive since the lack of need to posture through the time 2 contract frees up the VC to exploit its bargaining power, which results in greater underpricing. In other words, for a given α_1 the need to posture unambiguously increases the effective price per share observed in the second round.

However, since α_2^P is decreasing in α_1 , the effective price in the posturing equilibrium must rise as the VC's pre-existing stake grows. Indeed, α_2^P can become quite small for higher levels

of α_1 , or even approach zero, implying effectively infinite pricing. The reason why the stake size decreases in α_1 is because a higher initial stake makes it harder for the VC to convince the third parties that its signal is high (since it also gets a boost to the value of its initial stake by signaling a higher firm value). In this sense, creating the feedback loop from prices to value becomes more difficult. In order to ensure that firm value is maximized, the price signal must become stronger, even to the extent of overpricing relative to fundamentals.

Furthermore, the endogenous choice of α_1 *reinforces* the result that the need for posturing increases later round venture capital pricing, as it implies a higher α_1 in the Posturing model. Thus, the potential for greater overall efficiency in the Posturing equilibrium (which is reflected in both a higher α_1 that achieves optimal effort and a higher likelihood of funding since project NPV is higher) is directly tied to higher later stage (and lower early stage) prices.

Given these differences, cross sectional differences in price paths and efficiency can be expected depending on whether the Posturing or Hold Up model is applicable. Posturing will be applicable (or necessary) when *both*: (a) third party actions are particularly important *and* (b) the VC has important private information in later rounds. Putting all of these observations together, we have three important empirical implication of our model:

Implication 1: When Posturing is necessary, a steeper price path should be expected across VC financing rounds (corresponding to a larger up front stake purchase and a smaller later round stake purchase).

Implication 2: When Posturing is necessary, later stage financing rounds are more likely to exhibit prices that exceed fundamental value.

Implication 3: When Posturing is necessary, ventures should have both a higher probability of initial funding *and* greater rates of ex post success.

Next we explore some comparative statics of our model to derive additional implications. When s is uniformly distributed we have an unambiguous set of results with respect to \hat{s} , which measures how difficult it is to convince the third parties. (Note that all comparative statics in this section with respect to the various stake sizes (α 's) are derived under the assumption that there is an interior solution for that stake size in $(0, 1)$).

Proposition 6. Assume s is uniformly distributed on $[0, 1]$. Then, in equilibrium, α_1^P and α_1^H are increasing in \hat{s} , while α_2^P (α_2^H) is decreasing (increasing) in \hat{s} .

An increase in \hat{s} corresponds to an increase in the difficulty of convincing third parties that the firm's prospects are sufficiently good, i.e., their level of "skepticism" with respect to firm prospects. In the Posturing model this directly decreases α_2^P as the VC is required to signal a higher value by buying at a higher price. In addition, an increase in \hat{s} decreases the firm's ex ante expected profitability (an IPO will be feasible in fewer states). Thus, α_1^P increases to reduce E 's effort given the lower profitability. This indirectly decreases the second period stake and amplifies the direct effect of \hat{s} on the second stage price. The comparative static for the second stage stake is exactly the opposite in the Hold Up model, where an increase in \hat{s} means that the VC can extract even more surplus at time 2 when an IPO attempt is feasible (given its greater conditional profitability). However, the effect on the first stage stake is the same as, again, it is optimal to induce less effort. We thus have the following implication:

Implication 4: When third parties are harder to convince, a higher second stage price will be observed when Posturing is necessary (corresponding to a smaller later round stake purchase), while a lower second stage price will be observed when it is not (corresponding to a larger later round stake purchase). Thus, the difference in late stage pricing is amplified.

Another set of results comes from variation in the profitability of a late versus an early exit. In particular, consider an increase in π_2 holding π_1 constant. This will imply that the hold up problem is more significant since there is relatively less value available without additional

financing. This will make the Hold Up model relatively less efficient, while tightening the Posturing constraint (i.e., making it harder to signal since lower types have more incentive to pretend to be a higher type). In fact, we have the following result:

Proposition 7. In equilibrium, α_1^P (α_1^H) is invariant (decreasing) in π_2 , while α_2^P (α_2^H) is decreasing (increasing) in π_2 .

In the Posturing model, as it becomes harder to signal the VC must leave more ex post surplus to the entrepreneur, implying a lower late stage stake. However, this does not affect the first stage stake since the greater profitability of the project also implies higher optimal effort. In the Hold Up model, on the other hand, the increase in π_2 means that the VC gets an even greater proportion of the ex post surplus, so the first round stake must decrease to increase E 's effort. We thus have the following implication:

Implication 5: When the profitability of a late exit increases relative to the profitability of an early exit, and thus the hold up problem is more severe, a steeper price path will be observed when Posturing is necessary (corresponding to a smaller later round stake purchase), while a flatter price path will be observed when it is not (corresponding to a larger later round stake purchase and a smaller early round stake purchase). Thus, the difference in price paths is amplified.

We also have a number of comparative statics with respect to the investment costs.

Proposition 8. In equilibrium, α_1^P (α_1^H) is increasing (increasing) in I_1 and decreasing (increasing) in I_2 , while α_2^P is decreasing in I_1 and increasing in I_2 , and α_2^H is unaffected by both. Furthermore, the first stage price is decreasing in I_1 for both the Posturing and Hold Up models, and the second stage price in the Posturing model is increasing in I_1 .

When I_1 increases, all else equal the project is less profitable. In both models, this implies a larger stake for the VC at time 1 because it is optimal to reduce E 's effort when the project

is less profitable. In the Posturing model this also decreases the time 2 stake taken by the VC indirectly. Thus, in that model, transactions with higher later-stage pricing and lower early-stage pricing will correspond to those with higher initial investment costs. This yields the following implication:

Implication 6: An increase in early stage investment costs will predict a steeper pricing path when Posturing is necessary through both an increase in the first round stake (lower first round price) and a decrease in the second round stake (higher second round price). When Posturing is not necessary, the pricing path will also be steeper, but only through an increase in the first round stake (lower first round price).

An increase in I_2 both decreases the profitability of the project, reducing the optimal effort level, and affects the bargaining game and continuation payoffs for the later stage in the Posturing model. On balance, although optimal effort should be lower, we get a higher α_1 and lower early stage pricing in the Posturing model because the negative effect on E 's continuation payoff is dominant. In the Hold Up model, since the second stage bargaining game is not affected the only relevant force is the reduction in optimal effort, so the first round stake increases. This yields our final implication:

Implication 7: An increase in late stage investment costs will predict a decrease in the first round stake (higher first round price) when Posturing is necessary, and an increase in the first round stake (lower first round price) when it is not.

6. NUMERICAL EXAMPLE

In this section we illustrate the results of the model with a numerical example where the entrepreneur's effort cost function takes the form $c(e) = be^2$ and s is distributed uniformly on $[0, 1]$. We set the model's parameters to the following values: $I_1 = 1$, $I_2 = 4$, $\pi_1 = 16$,

$\pi_2 = 50$, and $b = 12$. We do not pin down the third parties' level of skepticism, q , or, equivalently, \hat{s} . Instead, we graph various equilibrium outcomes as functions of \hat{s} .

In Figure 2 below, we graph the equilibrium first-round stake, α_1 , for the two different models as a function of \hat{s} . In this and the following figures, the solid blue line corresponds to the Posturing model and the dashed green line corresponds to the Hold Up model. Note that $\hat{s} > 0.4$ is required given our constraint that $\underline{s} < \hat{s}$, and here we graph the range $\hat{s} \in [0.5, 1]$ to correspond to the range where α_1^P is positive.

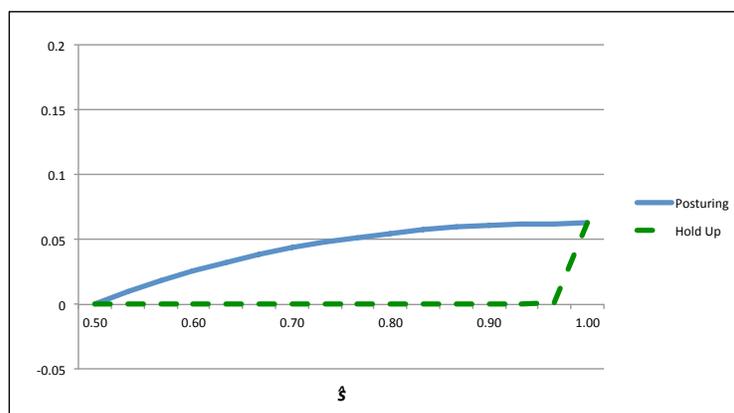


FIGURE 2. First Round Equity Stake as a Function of \hat{s}

As was shown analytically in Proposition 6, the first stage equity stake increases as the third parties become harder to convince and lower effort is optimal. Note that while the optimal first round stake for the VC is positive for the entire range of \hat{s} in the Posturing model, the Hold Up model is at the $\alpha_1 = 0$ constraint for most of the graph.

In Figure 3, we graph the equilibrium second-round stake, α_2 , conditional on $s \geq \hat{s}$ (i.e., given that the firm will remain independent and attempt an IPO) for the two different models as a function of \hat{s} . As derived analytically in Proposition 6, the equilibrium stake is decreasing as the third parties become harder to convince in the Posturing model, as a lower stake gives the higher implied pricing necessary to convince the third parties. Notably, in the Posturing

model the stake is significantly lower than in the Hold Up model, as in that model there is no need to posture and the VC can extract greater surplus from the entrepreneur.

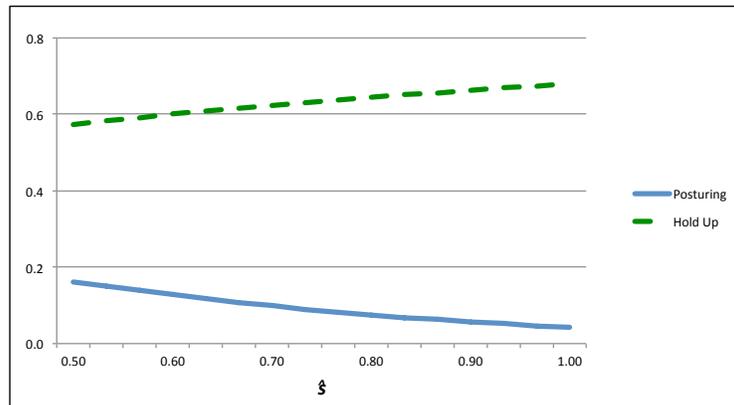


FIGURE 3. Second Round Equity Stake as a Function of \hat{s}

In Figure 4, we graph the effective implied price per share that corresponds to the equity stakes in Figure 3, i.e., $\frac{I_2}{\alpha_2}$. In addition, the thicker black line shows the actual value per share conditional on $s \geq \hat{s}$, or $\frac{1+\hat{s}}{2}\pi_2$. As this figure clearly shows, the Posturing model involves overpricing in the second round over a large part of the parameter space, while the Hold Up model never does. In addition, the overpricing in the Posturing model can be quite extreme as the third parties become harder to convince.

In Figure 5, we graph the equilibrium effort choice of the entrepreneur for each model as a function of \hat{s} . As third parties become harder to convince, the probability that the firm will remain independent and attempt an IPO falls, as does the overall value of the project. Thus, a lower effort level is optimal. However, notice that over most of the range, the effort level in the Hold Up model is significantly below the optimal level achieved in the Posturing model, due to the contracting inefficiencies arising from the VC's ex post opportunism. It is flat whenever the $\alpha_1 \geq 0$ constraint binds because for all such \hat{s} the achievable effort level is determined solely by E 's walkaway payoff of π_1 , which does not vary with \hat{s} .

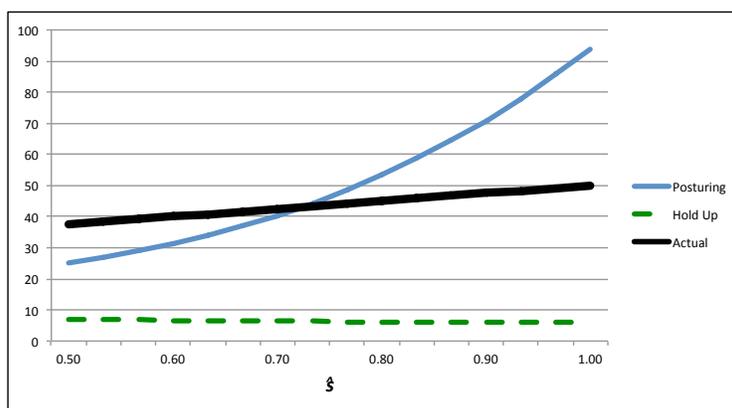


FIGURE 4. Second Round Implied Price Per Share as a Function of \hat{s}

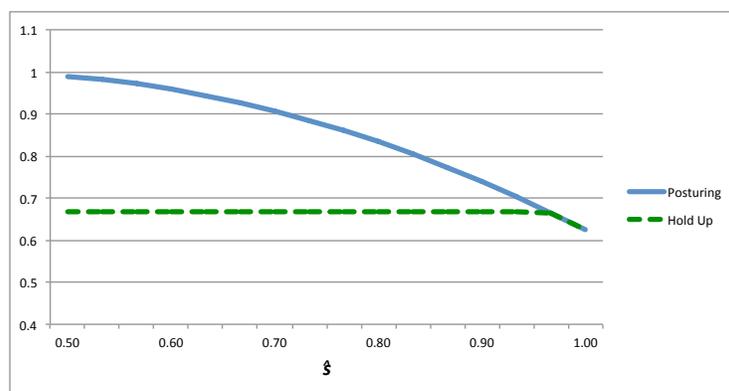


FIGURE 5. Equilibrium Effort Level as a Function of \hat{s}

In Figure 6 we graph the ex ante expected firm value for each model as a function of \hat{s} . For lower values of \hat{s} , the Hold Up model has a significantly lower firm value, as it is impossible to give the entrepreneur sufficient effort incentives given an absence of commitment that the VC will not expropriate E 's rents through renegotiation in the later round. Thus, for these cases posturing enables a more efficient contracting solution by committing the VC to lower surplus extraction in the second stage.

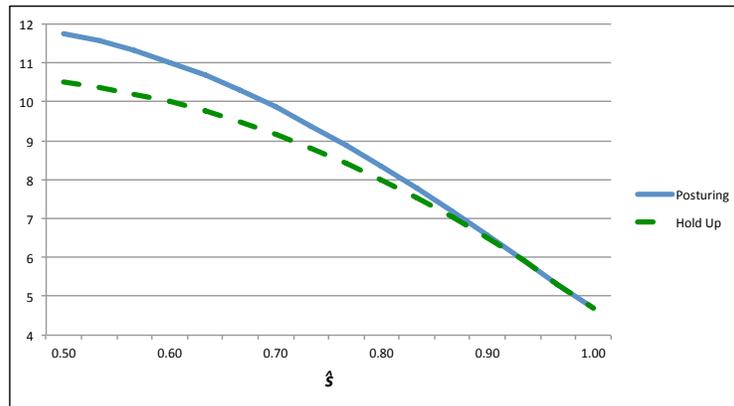


FIGURE 6. Ex Ante Expected Firm Value as a Function of \hat{s}

7. CONCLUSION

We show that the need to signal high values to third parties can have a significant impact on venture capital contracting. If potential competitors are eager to enter the firm's market, or employees, customers, suppliers, or future investors are reluctant to deal with the firm, the venture capitalist can have a strong incentive to set high prices in later financing rounds to create excitement and induce desired actions. We show that this can lead to overpricing, especially when the VC takes a large initial stake or the third parties are particularly skeptical. In addition, the need to posture can actually increase the venture's value since it enables more efficient ex ante contracting by limiting the opportunity for ex post opportunism. Our analysis provides numerous unique comparative statics and predictions.

APPENDIX 1

Throughout the paper we have maintained a reduced form characterization of third parties. In this appendix, we briefly discuss a more micro-founded version of our model when the third parties are potential competitors. Assume the firm faces a downward sloping demand curve, $D - \beta p$, where p is the price per unit. Assume the good state in the base model corresponds to the firm having the potential to invest I_2 in new technology that results in a low marginal cost, c_F , while the bad state corresponds to it having a prohibitively high marginal cost. Assume further that there is a competitor with a known marginal cost $c_P > c_F$. Finally, assume that if both firms are active in the market they compete a la Bertrand, and the competitor must make an entry/stay decision (where investing to enter or stay in the market costs c_E) before knowing the final state.

In this model a monopolist will set its price p to maximize total profit, $(D - \beta p)(p - c_i)$, which yields $p^* = \frac{D + \beta c_i}{2\beta}$ and maximized profit of $\frac{(D - \beta c_i)^2}{4\beta}$, where $i \in \{F, P\}$. Clearly, the competitor will enter/stay only if it has a high enough chance of being a monopolist. Conditional on an agreement between E and the VC to work toward an IPO, the competitor will enter/stay (assuming a financing equilibrium as derived in Proposition 1) if and only if $\frac{1 - s^*}{2} \frac{(D - \beta c_P)^2}{4\beta} \geq c_E$. Since the left-hand side clearly decreases in s^* , this implicitly defines a threshold \hat{s} for which if $s^* = \hat{s}$ in equilibrium, the competitor is just indifferent.

Similarly, the firm will find it worthwhile to invest I_2 in the low marginal cost technology, and thus work toward dominating the market and attempting an IPO, only if it is positive NPV to do so. If we assume c_P is sufficiently close to c_F that the firm's expected duopoly profit, $(D - \beta c_P)(c_P - c_F)$, is below π_1 , the firm will not work toward an IPO if it expects competition. Conditional on being a monopolist, it is profitable to move toward an IPO if $s \geq \underline{s} = \frac{I_2 + \pi_1}{\pi_2}$, where π_2 is replaced by $\frac{(D - \beta c_F)^2}{4\beta}$. From E and the VC's point of view, c_P and c_E affect only \hat{s} , so there will always exist a range of these costs such that $\hat{s} \in \{\underline{s}, 1\}$ and the

results of the Posturing model are directly applicable. In particular, the comparative static results with respect to \hat{s} now translate into comparative statics with respect to these costs. These will have the opposite sign to those in the base model since \hat{s} is decreasing in both c_P and c_E .

APPENDIX 2

Proof of Proposition 1: Funding the firm is profitable ex ante if, at the optimal e ,

$$e(Pr[s \geq \hat{s}](E[s|s \geq \hat{s}]\pi_2 - I_2) + Pr[s < \hat{s}]\pi_1) + (1 - e)I_1 - I_1 - c(e) > 0 \quad (15)$$

$$\implies e(Pr[s \geq \hat{s}](E[s|s \geq \hat{s}]\pi_2) + Pr[s < \hat{s}]\pi_1) > e(I_1 + Pr[s > \hat{s}]I_2) + c(e)$$

In equilibrium, since E has the bargaining power the VC will be held to a zero expected payoff (E will demand a transfer equal to the VC's expected payoff under any proposed contract in equilibrium), i.e., the VC's participation constraint will be satisfied as an equality. Given the assumption that the VC gets the full payoff I_1 upon liquidation of a non-viable firm, this implies

$$e(Pr[s \geq \hat{s}](E[s|s \geq \hat{s}]\pi_2(\alpha_1(1 - \alpha_2) + \alpha_2)) - I_2) + Pr[s < \hat{s}]\pi_1\alpha_1 + (1 - e)I_1 - I_1 - \tau = 0 \quad (16)$$

\implies

$$\alpha_1(Pr[s \geq \hat{s}]E[s|s \geq \hat{s}](1 - \alpha_2)\pi_2 + Pr[s < \hat{s}]\pi_1) + \alpha_2 Pr[s \geq \hat{s}]E[s|s \geq \hat{s}]\pi_2 - Pr[s \geq \hat{s}]I_2 = I_1 + \frac{\tau}{e} \quad (17)$$

must hold in equilibrium. It is straightforward to show that with $\tau = 0$, this last expression corresponds to the expression one gets by setting the right hand side of (6) equal to the right hand side of (3). In other words, any pair (α_1, α_2) that induces optimal effort also sets the VC's expected payoff to zero assuming $\tau = 0$.

Now assume the project is ex ante profitable and consider a proposed contract with $\alpha_2 = 0$. Then solving (16) for α_1 yields $\alpha_1 = \frac{I_1 + Pr[s \geq \hat{s}]I_2}{Pr[s \geq \hat{s}]E[s \geq \hat{s}]\pi_2 + Pr[s < \hat{s}]\pi_1} \equiv \alpha_1^{CC}$, which, by inspection of (15), is between zero and one whenever the project is positive NPV. Thus, a contract with $\alpha_2 = 0$, $\alpha_1 = \alpha_1^{CC}$, and $\tau = 0$ gives first best effort and satisfies the VC's participation constraint with equality while allowing E to capture the full surplus, and is therefore optimal and achieves first best. Finally, it is straightforward to show that raising α_2 above zero while lowering α_1 so as to keep (16) satisfied will maintain the features of this equilibrium as long as α_1 and α_2 remain in the range $[0, 1]$, which must be possible over some range since α_1^{CC} is strictly in that range. **QED**

Proof of Proposition 2: Given the renegotiation offer (8), the entrepreneur's effort choice problem (6) becomes $c'(e) = (1 - \alpha_1)\pi_1$. When (9) holds, the right-hand side of this equation is always less than the right hand side of (3), so the optimal contract will set $\alpha_1 = 0$ to elicit the maximum possible effort. Note that it is always optimal for the VC to make the renegotiation offer when the product is viable and $S = H$, so the lack of effort is the only source of inefficiency in this contract, and no other changes to the contract can induce greater effort. Now note that since any pair (α_1, α_2) that induces optimal effort (i.e., sets the right hand side of (6) equal to the right hand side of (3)) satisfies the VC's participation constraint with equality given $\tau = 0$, the optimal contract derived here must satisfy the VC's participation constraint with equality at a positive τ (a negative α_1 would be required to induce optimal effort given $\alpha_2 = \alpha_2^H$, and the VC's expected payoff increases in α_1). This proves the first part of the result. For the second part of the result, it suffices to note that since optimal effort can be achieved with a positive α_1 when (9) does not hold, from above the VC's participation constraint will be satisfied with equality at that optimal α_1 with $\tau = 0$. **QED**

Proof of Proposition 3: Consider a proposed equilibrium as in the proposition for any given $s^* \geq \hat{s}$. Using Bayes' rule, the third parties' posterior beliefs about s given an offer of $\alpha_2 = \alpha_2^P$ are given by $E[s|\alpha_2 = \alpha_2^P] = E[s|s \geq s^*] \geq q$. Given these beliefs, it is optimal for E to accept the offer if his expected payoff exceeds $(1 - \alpha_1)\pi_1$. This is ensured since funding is positive NPV (since only VCs with $s > \underline{s}$ make offers, and it is optimal to attempt an IPO whenever $s \geq \hat{s}$), and the VC with $s = s^*$ is made indifferent at $\alpha_2 = \alpha_2^P$. The latter implies that E at least breaks even relative to the early exit option payoff of $(1 - \alpha_1)\pi_1$ conditional on $s = s^*$, given the new funding contract and a late exit attempt, and he can only do better conditional on a higher s since his stake is the same for all such s . VCs with $s < s^*$ strictly prefer to let the firm be sold given the required stake offer α_2^P , so are happy to make no offer. Finally, out-of-equilibrium third party beliefs that any stake offer other than α_2^P comes from a low type (e.g., from a type with $s = 0$) prevents deviation by any VC with $s \geq s^*$ to any other α_2 since it will lead to rejection. **QED**

Proof of Proposition 4: Since it optimizes the effort level, and the subsequent stage 2 sub game ensures sufficiently strong third party beliefs, the offer of α_1^P (if it is non-negative) is optimal for E if it makes the VC accept and keeps the VC at its participation constraint, which is an ex ante expected payoff of zero. It was shown in the proof of Proposition 1 that this holds with a transfer of $\tau = 0$ whenever the right hand side of (6) is equal to the right hand side of (3). The fact that $\alpha_1^P > \alpha_1^H$ follows directly from the fact that $\alpha_2^P < \alpha_2^H$ and that both α_1^P and α_1^H are derived from setting the right hand side of (6) equal to the right hand side of (3), which yields (17) assuming $\tau = 0$, and it is clear that the left hand side of (17) is increasing in both α_2 and α_1 . If α_1^P is negative, as in the Hold Up model the optimal contract must set $\alpha_1 = 0$ to elicit the maximum possible effort (the lack of effort is the only source of inefficiency in this contract, and no other changes to the contract can induce greater effort). Also as noted above, since any pair (α_1, α_2) that induces optimal effort (i.e., sets the right

hand side of (6) equal to the right hand side of (3)) satisfies the VC's participation constraint with equality given $\tau = 0$, the optimal contract derived here when $\alpha_1^P < 0$ must satisfy the VC's participation constraint with equality at a positive τ (a negative α_1 would be required to induce optimal effort given $\alpha_2 = \alpha_2^H$, and the VC's expected payoff increases in α_1). **QED**

Proof of Proposition 5: Consider cases where (9) holds, so that there is less than first best entrepreneurial effort in the Hold Up model, but it is still profitable for E to seek funding under the optimal contract. Since $\alpha_2^P < \alpha_2^H$ and $\alpha_1^P > \alpha_1^H$, and there are no differences in the outcomes of the Hold Up and Posturing models except differences in entrepreneurial effort and therefore the probability of a viable product, $\alpha_1^P > 0$ will sometimes hold, in which cases the equilibrium in the Posturing model will achieve the first best (leading to higher firm value and greater efficiency than in the inefficient Hold Up model). Whenever $\alpha_1^P < 0$ holds, both models will have $\alpha_1 = 0$ in equilibrium and will have less than first best effort. However, the fact that $\alpha_2^P < \alpha_2^H$ implies greater effort in the Posturing model equilibrium, and hence higher firm value and greater efficiency. It also implies that seeking funding is always positive NPV for E in the Posturing model if it is positive NPV in the Hold Up model. Now assume (9) holds, but it is not positive NPV for E to seek funding under the optimal ($\alpha_1 = 0$) contract in the Hold Up model. In some cases, it will still be positive NPV to seek funding in the Posturing model since, as shown above, equilibrium effort will be closer to first best, and thus firm value will be higher. Finally, when (9) does not hold, full efficiency is achieved in both models as both α_1^H and α_1^P are positive and induce globally optimal effort. **QED**

Proof of Proposition 6: The result for α_1^P follows by taking the derivative of (14) with respect to \hat{s} using a uniform distribution for s on $[0, 1]$ (i.e., replacing as follows in (14): $E[s|s \geq \hat{s}] = \frac{1+\hat{s}}{2}$, $Pr[s \geq \hat{s}] = 1 - \hat{s}$, and $Pr[s < \hat{s}] = \hat{s}$), which yields $\frac{2(1-\hat{s}^2)(I_1+I_2)}{(1+\hat{s}^2)^2\pi_1} > 0$. For α_1^H , performing the same substitution and taking the derivative of (11) yields $-\frac{I_2+\pi_1-\hat{s}\pi_2}{\pi_1} > 0$

where the sign follows from the fact that $I_2 + \pi_1 - \hat{s}\pi_2 < 0$ holds given $\hat{s} > \underline{s}$. For α_2^P notice from (13) that it is decreasing in α_1 , so the indirect effect through α_1 is negative, and it is also directly decreasing in $s^* = \hat{s}$. For α_2^H , the result is obvious by inspection from its definition.

QED

Proof of Proposition 7: All of the results are obvious by inspection from the definitions of the various stake sizes. **QED**

Proof of Proposition 8: The results for α_1^P , α_1^H , and α_2^H follow by inspection from (14), (11), and (8). For α_2^P , note from (13) that it is directly increasing in I_2 and decreasing in α_1 , so that the direct and indirect effects of I_2 are reinforcing, and also note that it is unaffected by I_1 other than through α_1 . The result for the second stage price per share in the Posturing model, $\frac{I_2}{\alpha_2^P}$, with respect to I_1 follows since it does not depend directly on I_1 . The derivative for the first stage price per share in the Posturing model is $\frac{\partial \frac{I_1}{\alpha_1^P}}{\partial I_1} = \frac{\frac{Pr[s \geq \hat{s}]I_2(\hat{s} - E[s|s \geq \hat{s}])}{\pi_1(\hat{s}Pr[s < \hat{s}] + E[s|s \geq \hat{s}]Pr[s \geq \hat{s}])}}{\alpha_1^{P2}} < 0$. The derivative for the first stage price per share in the Hold Up model is $\frac{\partial \frac{I_1}{\alpha_1^H}}{\partial I_1} = \frac{Pr[s \geq \hat{s}](I_2 + \pi_1 - E[s|s \geq \hat{s}]\pi_2)}{\alpha_1^{H2}} < 0$. **QED**

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