

Venture Capital and Capital Allocation

GIORGIA PIACENTINO*

ABSTRACT

I show that venture capitalists' motivation to build reputation can have beneficial effects in the primary market, mitigating information frictions and helping firms go public. Because uninformed reputation-motivated venture capitalists want to appear informed, they are biased against backing firms—by not backing firms, they avoid taking low-value firms to market, which would ultimately reveal their lack of information. In equilibrium, reputation-motivated venture capitalists back relatively few bad firms, creating a certification effect that mitigates information frictions. However, they also back relatively few good firms, and thus, reputation motivation decreases welfare when good firms are abundant or profitable.

DELEGATED INVESTORS WISH TO BE perceived as skilled in order to generate “flows,” that is, to attract new investors and retain existing ones. This motivation to build a reputation for being skilled can distort their trades in secondary markets. For example, delegated investors may trade too much in an attempt to appear informed, even when they are not. Such excessive portfolio churning can decrease secondary market efficiency (Dow and Gorton (1997), Dasgupta and Prat (2006, 2008), Guerrieri and Kondor (2012)). However, delegated investors play an important role not only in secondary markets, where their trading behavior affects market efficiency, but also in primary markets, where their investment behavior affects real efficiency. In particular, venture capital firms (VCs) decide which firms to back and thus which projects go ahead. In this paper, I ask whether VCs' reputation motivation leads to inefficiencies in primary markets. Specifically, I examine whether reputation motivation induces VCs to back the wrong firms in an attempt to appear skilled.

*Giorgia Piacentino is with Columbia University and CEPR. I thank three anonymous referees, the Associate Editor, and the Editor, Bruno Biais. I am also grateful to Ulf Axelson; the late Sudipto Bhattacharya; Sugato Bhattacharya; Philip Bond; Mike Burkart; Amil Dasgupta; James Dow; Jason Roderick Donaldson; Alex Edmans; Daniel Ferreira; Itay Goldstein; Radhakrishnan Gopalan; Denis Gromb; Christian Julliard; Ohad Kadan; Peter Kondor; Todd Milbourn; Daniel Paravisini; Christopher Polk; Uday Rajan; Anjan Thakor; David Thesmar; Dimitri Vayanos; Michela Verardo; Kathy Yuan; Konstantinos Zachariadis; Hongda Zhong; and audiences at Amsterdam Business School, Arizona State University, Bocconi University, the 2013 EFA meeting, EIEF, Federal Reserve Board of Governors, the 2013 FIRS conference, HEC Paris, the 2017 Institutional Investors and Corporate Governance conference at the Swedish House of Finance, UBC, UNC, University of Maryland, University of Michigan, Stockholm School of Economics, University of Pennsylvania, University of Warwick, and Washington University in St. Louis. I have read the *Journal of Finance's* disclosure policy and have no conflict of interest to disclose.

DOI: 10.1111/jofi.12756

To address these questions, I develop a model in which a VC may be reputation-motivated, instead of purely profit motivated. Surprisingly, I find that, in equilibrium, the VC's profits can be higher than they would be if it were just trying to maximize them. The reason is that reputation motivation changes a VC's behavior, leading it to reduce the number of firms it backs, and this creates a certification effect that mitigates information frictions at the time of IPO. Reputation motivation is not all good, however, as it can also lead a VC not to back some relatively good firms. Thus, reputation motivation leads a VC to back not only fewer bad firms, but also fewer good firms. The net effect on total welfare and VC profits therefore depends on the proportion and quality of good firms in the market.

Model Preview. A penniless start-up firm requires outside finance for an investment that may be good or bad. It looks for a VC to back it, that is, to provide capital and expertise. If the firm receives backing, it gives the VC an equity stake and invests. Later, the firm raises capital from uninformed bidders in an initial public offering (IPO), in which the VC retains its stake in the firm. Finally, the long-run value of the investment is realized.

The VC can be skilled or unskilled. If it is skilled, it can observe whether the firm (i.e., its investment) is good or bad; if it is unskilled, it observes nothing. I consider two cases. First, the VC may be *profit-motivated*, that is, it wants to back the firm whenever it expects to make a profit for its current investors. Second, the VC may be *reputation-motivated*, that is, it wants to maximize the market's belief that it is skilled, so as to maximize the capital it can raise from future investors.

Results Preview. I first characterize the equilibrium with a profit-motivated VC. A skilled VC knows the quality of the firm. As a result, it does not back bad firms, while it backs good firms as long as it anticipates being able to take them to IPO. Hence, a skilled VC "filters out" bad firms. In contrast, an unskilled VC does not know whether the firm is good or bad but it knows that the market believes that VC-backed firms are better than average, due to the skilled VC's filtering. Thus, if the unskilled VC backs the firm, it raises cheap capital at the time of the IPO, that is, it is subsidized by pooling with the positively informed skilled VC. As a result, the unskilled VC may also back the firm, despite its lack of information, as doing so maximizes its expected profits. However, this may be socially inefficient. Indeed, the unskilled VC overinvests, that is, it may still back a firm with negative net present value (NPV). When the average NPV is low enough, the unskilled VC's overinvestment can reduce the average quality of VC-backed firms so much that IPO bidders are unwilling to provide capital. Thus, in anticipation of being unable to IPO, skilled VCs do not back firms even when they know they are good, that is, the collapse of the IPO market causes the VC market to break down.

What changes if the VC is reputation-motivated? In this case, an unskilled VC is averse to backing a firm that might end up being bad, but less averse to *not* backing a firm that might end up being good. Since the firm's value is revealed only if the VC backs it, the market can determine whether the VC wrongly backed a bad firm but not whether the VC wrongly rejected a good firm.

Put differently, the market can distinguish between false positives and true positives, but cannot distinguish between false negatives and true negatives. This biases the unskilled VC toward “negatives,” that is, toward not backing the firm, which makes the unskilled reputation-motivated VC *conservative*—it backs firms less frequently than an unskilled profit-motivated VC.

When the unskilled reputation-motivated VC rejects a firm, it is doing something that decreases its profits—if it just maximized its profits, it would act like the unskilled profit-motivated VC and overinvest to get the IPO subsidy from the skilled VC. However, even though it is not trying to maximize them, these profits can still be higher than those of the unskilled profit-motivated VC in equilibrium. The reason is that its conservatism leads to a certification effect that can increase efficiency in two ways. First, it can prevent market breakdowns: since unskilled reputation-motivated VCs back firms relatively rarely, many VC-backed firms are backed by positively informed skilled VCs. The market therefore infers that VC-backed firms are probably good. This effect mitigates information frictions and helps firms go public. Second, even absent market breakdowns, a VC’s conservatism can increase aggregate efficiency. Relative to the profit-motivated VC, the reputation-motivated VC backs fewer good firms, but also fewer bad firms. The net effect of this behavior for social efficiency depends on firms’ average NPV. If it is negative, aggregate efficiency is higher with reputation-motivated VCs, as they back firms less often than profit-motivated VCs. In contrast, if firms’ average NPV is positive, aggregate efficiency is lower with reputation-motivated VCs, as in this case, the costs of backing fewer good firms outweigh the benefits of backing fewer bad firms.

Below, I place a bit more emphasis on the negative-NPV case, and hence on the positive effects of reputation motivation because I think this case may be more important in practice. VC partners “source a few thousand opportunities, invest in a handful, and get returns from a few”; indeed, “almost 80 percent of all investments fail” (Ramsinghani (2014, p. 69 and p. 6)). That said, although the total population of firms that VCs could possibly back may have negative average NPV, the set of firms in my model could represent a subset of this population, with the worst already partially filtered out. Under this interpretation, the positive average NPV case becomes important too.

Extensions and Robustness. I show that the positive side of reputation motivation is robust to a number of extensions, two of which are particularly important. First, I include adverse selection among IPO bidders, so that the firm must issue shares at a discount to induce uninformed bidders to participate. I show that the results are robust to this more realistic model of an IPO. More importantly, I show that VCs’ reputation motivation can improve welfare even if the average NPV is positive. Indeed, by not backing firms with low but positive NPV—something that would typically be inefficient—the certification effect of reputation-motivated VCs is strong enough to overcome adverse-selection-induced market breakdowns.

Second, I allow the unskilled VC to be partially informed. In particular, I assume that it gets a continuous signal about the quality of the firm, so it backs firms only if its signal is above a threshold. As in the baseline, an

unskilled reputation-motivated VC backs firms less often than an unskilled profit-motivated VC, now in the sense that it applies a higher threshold than the profit-motivated VC does. I show that my results are robust to this more realistic definition of “unskilled.” More importantly, I can map the threshold signal to the hurdle rate that VCs apply to investments, and hence generate the additional empirical prediction that the hurdle rate that VCs use is increasing in their reputation motivation.

In further extensions, I show that if either (i) the firm has assets in place, so that the market may learn the quality of the firm even if it does not get VC backing, or (ii) there is a convex flow-performance relationship, so the VC maximizes a convex function of the market’s beliefs about its skill, then the results are qualitatively similar, although weaker. The results are also qualitatively similar, but stronger, if (iii) the VC sells its stake at the time of the IPO, so that even a negatively informed VC free rides on positively informed VCs. Finally, I show that my main results are robust to relaxing some of the other simplifying assumptions that I make in the baseline model.

Layout. The paper proceeds as follows. Next, I discuss the model’s empirical relevance and related literature. In Section I, I present the model. In Section II, I characterize the equilibria, both for profit-motivated and reputation-motivated VCs. In Section III, I compare these two equilibria and show that reputation motivation increases IPO prices, prevents market breakdowns, and increases aggregate output for some parameters. In Section IV, I consider extensions and show that the results are robust to a number of different specifications. I conclude in Section V. The Appendix contains the proofs and equilibrium refinements.

A. *Realism and Empirical Content*

Assumptions. My model is based on the assumption that reputation motivation matters for VCs, in the sense that they care about building their reputation over and above maximizing profits. This reflects practice, due to the fixed fees they charge on the capital flows that they attract, as described in more detail in Section I.D. Further, as in my model, the ability to pick good firms is arguably the most important component of VC skill—VCs “often receive and evaluate thousands of business plans each year. Therefore, a [VC] firm’s ability to effectively and efficiently identify winning investment proposals is critical to its success” (Nelson, Wainwright, and Blaydon (2004, p. 1); see also, for example, Gompers et al. (2006)).

Proxies. To compare my model with empirical findings, the challenge is to identify proxies for VCs’ reputation motivation. In the model, reputation-motivated VCs highly value (i) the future relative to the present, (ii) inflows of client capital relative to immediate fund performance, and (iii) the reputation they have at stake to lose.¹ Each of these components finds natural proxies:

¹ Formally, point (iii) corresponds to a slightly different notion of reputation than points (i) and (ii) within the model. It is not about the difference between VCs’ being profit-motivated and

(i) reputation-motivated VCs are younger,² (ii) reputation-motivated VCs have higher fixed fees relative to performance fees (so that they need to increase assets under management to increase revenue),³ and (iii) reputation-motivated VCs are large⁴ and have strong track records.⁵ More generally, the reputation-motivated VCs in my model could correspond to real-world VC firms and other delegated primary market investors that compete for flows, whereas the profit-motivated “VCs” in my model could correspond to angel investors and other nondelegated primary market investors that do not compete for flows.

Consistent Stylized Facts. Using the proxies for reputation motivation discussed above, my model is consistent with a number of empirical findings. First, the result that reputation motivation helps prevent market breakdowns (see Proposition 3) is consistent with the finding that the more reputable VCs are, the more likely they are to lead their portfolio companies to successful IPOs (Nahata (2008), Krishnan et al. (2011)). Second, the result that firms backed by more reputation-motivated VCs have higher IPO values (see Lemma 5) is consistent with the empirical finding that VC-backed firms have higher prices than non-VC-backed firms at IPO (Megginson and Weiss (1991)). My results are also broadly consistent with the fact that VC-backed companies are more likely to go public when backed by a more reputable VC (Hsu (2004), Puri and Zarutskie (2012)). Further, my emphasis on how VCs help overcome information frictions is consistent with practice, since “[v]enture capitalists concentrate investments in early stage companies and high technology industries where informational asymmetries are significant” (Gompers (1995, p. 1462)).

Unique Predictions. A number of the predictions above are not unique to my model, but are also consistent with models of direct VC certification in which VCs add value through selection or direct monitoring. However, my finding that reputation motivation makes VCs conservative leads to the following novel predictions.

First, it suggests that reputation-motivated VCs back fewer firms, applying hurdle rates so high that they choose not to support some profitable investments (see Proposition 9). One way to test this would be to use the ratio of VCs’ invested to committed capital, that is, the amount that they have invested in firms divided by the amount they have raised from investors. This ratio measures VCs’ proclivity to back firms and hence should be decreasing in VCs’ reputation motivation. The prediction is broadly consistent with evidence that

reputation-motivated, but rather about how reputable reputation-motivated VCs are. However, my empirical predictions are not sensitive to this definitional distinction. Indeed, in Lemma 3, I show that more reputable reputation-motivated VCs act “more reputation motivated” in the sense that they are more conservative (see also footnote 20).

² Chevalier and Ellison (1999) use age as a proxy for mutual funds’ reputation motivation and Gompers (1996) and Lee and Wahal (2004) use age as a proxy for VCs’ reputation motivation.

³ There is significant variation in VC compensation (see Section I.D). VCs with a larger performance fee relative to the fixed fee are likely to be less reputation motivated than VCs with a relatively lower performance fee (see Dasgupta and Piacentino (2015) for a discussion).

⁴ Gompers and Lerner (1999a, 1999b) use size as a proxy for reputation.

⁵ See, for example, Krishnan et al. (2011) and Sørensen (2007).

VCs rarely back firms. Gompers et al. (2016), for instance, observe that “VCs start with a pipeline of hundreds of potential opportunities and narrow those down to make a very small number of investments” (p. 17). Moreover, the most reputable VCs—those that are the largest or most successful—appear to back firms the least, in line with the hurdle rate being increasing in reputation in my model (cf. Corollary 5). Indeed, according to Gompers et al. (2016), “[l]arge VC firms and more successful VC firms . . . initiate due diligence on more firms per closed deal than their smaller or less successful peers” (p. 17). Ex post evidence on the success of VC-backed firms is also consistent with reputation motivation leading backers to choose fewer firms, and with those firms being more successful at the time of IPO. Indeed, Kaplan and Lerner (2010) estimate that even though fewer than 0.025% of firms get VC backing, these firms account for 60% of all IPOs.

Second, the model generates new predictions about how the market reacts to investing rarely or applying a high hurdle rate. Since the most reputation-motivated VCs make the highest profits (at least in normal times when the average NPV is negative),⁶ investors should want to invest with them. Hence, investor capital should chase VCs that apply high hurdle rates, investing rarely but making exceptional profits when they do. This is consistent with the seemingly excessive amount of attention that investors pay to VCs’ best investments: VCs get famous and win investors by backing unicorns more than by making consistently high returns. For example, one might know that Sequoia Capital backed LinkedIn and Google or that Benchmark Capital backed Twitter and Zillow, but one might not know these VCs’ average returns.

Third, the model suggests that reputation motivation has different effects on IPO activity depending on the state of the economy. In particular, in good times, when the average investment opportunity has positive NPV, an increase in reputation motivation should lead to fewer IPOs (because reputation-motivated VCs back fewer firms), whereas in normal times, when the average opportunity has negative NPV, an increase in reputation motivation could lead to more IPOs (because reputation motivation prevents market breakdowns when firms have negative average NPV).

The proxies described above help make these predictions testable.

B. Related Literature

My paper contributes to the literature on reputation motivation/career concerns⁷ in financial markets. Unlike most of this literature, which focuses on secondary markets, I focus on primary markets, and on VCs in particular.⁸ My

⁶ This is an immediate consequence of Proposition 4.

⁷ The distinction I make between models of “reputation motivation” and “career concerns” is that in the former, agents know their types, whereas in the latter, they do not.

⁸ One other paper that looks at VC reputation in primary markets is Khanna and Matthews (2017). The authors highlight a downside of high VC reputation: it can exacerbate hold-up problems and lead good firms to lose VC backing.

paper is the first to connect VCs' reputation motivation with market breakdowns at the time of IPO. I uncover a positive side of reputation motivation. This contrasts with results in this literature, which suggest that the "churning" of career-concerned agents has adverse effects (see Scharfstein and Stein (1990), Dasgupta and Prat (2006, 2008), and Guerrieri and Kondor (2012)).⁹ Reputation motivation can be beneficial in my setup because it distorts the actions of unskilled VCs in such a way that the actions of skilled VCs become more informative, mitigating the inefficiencies that result from asymmetric information.¹⁰

This paper builds on a large literature on career concerns initiated by Fama (1980). Perhaps, the most closely related paper in this literature is Chen (2015), who builds on the model in Hölmstrom (1999) to show that reputation-motivated agents tend to overinvest when they know their skill. In contrast, I show that if the agent's skill reflects his ability to understand the state of the world (as in, for example, Hölmstrom and Ricart i Costa (1986), Scharfstein and Stein (1990), and Gibbons and Murphy (1992)), rather than to generate high output, the agent may underinvest.

Asymmetric learning about the agent's skill also appears in Milbourn, Shockley, and Thakor (2001) and Hirshleifer and Thakor (1994). Milbourn, Shockley, and Thakor (2001) show that a career-concerned manager overinvests in information because this improves the odds of rejecting a bad project. In their paper, the career-concerned agent invests more than it would if it were profit-motivated, in contrast to my model in which a reputation-motivated VC invests less than it would if it were profit-motivated. The main reason for this difference is that in my model, the VC knows its type, whereas in their model, the agent does not. Hirshleifer and Thakor (1994) find that skilled managers are conservative in the sense that they are reluctant to undertake projects that might fail conspicuously, and that this can help firms raise debt from investors who want to avoid downside risk.¹¹ This result is somewhat analogous to my finding that being reputation-motivated, and not actively trying to maximize profits, can increase VCs' profits in equilibrium. My results on market breakdowns and the other effects of asymmetric information, however, do not have parallels in their paper.

Since a VC's decision to back a firm affects the firm's ability to go public in my model, it is also related to papers on feedback effects between financial

⁹ Dow and Gorton (1997) also show that there may be a positive effect of institutional investors' "endogenous noise trading," since it may provide risk-sharing opportunities.

¹⁰ Other papers, following Hölmstrom (1999), also find positive effects of career concerns. In these papers, career concerns provide agents with implicit incentives that make up for a lack of explicit incentives, basically making them more profit-motivated. In my paper, in contrast, reputation motivation makes VCs *less* profit-motivated, but can end up helping them generate higher profits in equilibrium through the effect on the IPO price.

Finance papers that explore positive effects of reputation motivation include Booth and Smith (1986) and Chemmanur and Fulghieri (1994). In these papers, an underwriter's reputation motivation helps align the incentives of a firm raising capital with those of its capital providers.

¹¹ Such excessive "conservatism" is a common feature of career concerns models. See, for example, Hölmstrom (1999), Prendergast and Stole (1996), and Zwiebel (1995).

markets and investment such as Boot and Thakor (1997), Bond, Goldstein, and Prescott (2010), Dow and Rahi (2003), Bond and Goldstein (2015), Dow, Goldstein, and Guembel (2016), Edmans, Goldstein, and Jiang (2015), Fulghieri and Lukin (2001), Goldstein and Guembel (2008), Goldstein and Yang (2014), and Subrahmanyam and Titman (2001).

I. Model

In this section, I present the model. A firm gets initial backing from a VC that takes an equity stake in the firm. Later, the VC takes the firm public in an IPO. The value of the firm is realized after the IPO. Critically, the VC's incentives reflect either *profit motivation* or *reputation motivation*.

A. Players

Firms. In my model economy, there is a firm that has one of two qualities $\theta \in \{g, b\}$, where g stands for “good” and b for “bad.” The firm is good with probability φ . The final value of the firm of type θ is V_θ . For the value to be realized, the firm must first get initial backing from a VC and later raise capital I in an IPO. I refer to the NPV of a firm of type θ as $\text{NPV}_\theta := V_\theta - I$ and to the average NPV as $\overline{\text{NPV}} := \varphi V_g + (1 - \varphi)V_b - I$. If the firm fails to obtain backing from the VC or does not go public successfully, it is worth zero.¹²

VCs. There is a VC that has one of two types, denoted by s and u , where s stands for “skilled” and u for “unskilled.” The VC is skilled with probability $\gamma \in (0, 1)$. Each type of VC (privately) knows whether it is skilled. The difference between the skilled VC and the unskilled VC is that the skilled VC knows the quality of the firm, whereas the unskilled VC does not. I refer to a skilled VC that observes $\theta = g$ as “positively informed” and to a skilled VC that observes $\theta = b$ as “negatively informed.” I denote the VC's action as $a = 1$ if it backs the firm and $a = 0$ if it does not. I assume, for simplicity, that whenever the VC backs the firm, it owns all of the shares in the firm.¹³ Later, when the firm raises capital at the IPO, the VC retains its shares (although it is diluted by new shares).¹⁴

¹² The assumption that the firm has zero value if it does not get funding is realistic for the kinds of start-up ventures that VCs specialize in. That said, I explore an extension in which the unfunded firm has “assets in place” with nonzero value in Section IV.A. The results are qualitatively the same as in the baseline model.

¹³ None of the results would change if the VC instead received a smaller fixed fraction of the firm; this would just amount to a linear transformation of its payoff. Even so, note that I assume that the VC either backs the firm or not, but I do not model the precise terms at which the VC acquires its stake. Hence, the VC cannot signal its information when it backs the firm, for example, by buying at a high price. I abstract from this signaling problem mainly for simplicity. However, in practice, outsiders cannot observe many of the terms of these deals, and hence a VC's ability to signal is limited.

¹⁴ This is realistic since VCs usually do not sell shares at the time of the IPO. Some VCs exit after a “lock-up” period of several months after the IPO, whereas other VCs continue to hold shares long after the lock-up period (see Gompers and Lerner (1998, p. 2164)). Nevertheless, in Section IV.B,

B. IPO

If the VC backs the firm, the firm may sell an equity stake $\alpha \in (0, 1)$ in an IPO to raise capital I from competitive bidders.^{15,16} These IPO bidders are uninformed but they observe whether the firm receives VC-backing, which allows them to update their beliefs about its quality. If the IPO bidders provide I , they get the stake α in the firm and the IPO is successful.

I use the variable ι to indicate the success of the IPO: $\iota = 1$ if the IPO is successful and $\iota = 0$ otherwise, that is, $\iota = 0$ if the VC does not back the firm or if it backs the firm and the IPO fails.

C. Timeline

The sequence of moves is as follows. First, the VC either backs the firm, $\alpha = 1$, or does not, $\alpha = 0$. Second, if the VC has backed the firm, the firm may go public via an IPO. If IPO bidders provide I , then the IPO is successful, $\iota = 1$; otherwise, the IPO is unsuccessful, $\iota = 0$. Finally, if the IPO is successful, the long-run value of the firm V_θ is realized and publicly observed; otherwise, the value of the firm is zero. This sequence of moves is illustrated in Figure 1.

D. The VC's Payoff: Profit Motivation and Reputation Motivation

The VC's payoff takes different forms in different parts of the paper, reflecting the different preferences of real-world VCs. VC compensation has two parts: a fixed fee and a variable fee or "performance fee," which is typically a fixed fraction of the VC's profits. These fees vary from VC to VC. For example, younger VCs charge a higher fixed fee and a lower performance fee than older and larger VCs. The fixed portion of compensation is usually between 1.5% and 3% of net asset value and the variable portion is usually about 20% of profits (see Gompers and Lerner (1999a)). While the ability to make profits is key to obtaining the performance fee, the ability to build *reputation* is key to

I consider a variation of the model in which the VC exits at the IPO. All of my main results go through in that setting.

¹⁵ Note that I have assumed that the stake α is *strictly* less than one. This assumption is standard in IPO models: if there are n initial shares and N new shares sold in the IPO, then the largest fraction of the firm that the IPO bidders can get is $n/(n + N) < 1$. This rules out cases in which the VC sells the entire firm and gets nothing for it. Without this assumption, such cases could arise in equilibrium. These equilibria are unrealistic, as they require that a VC goes through the trouble of backing a firm knowing that it will never profit from it. The assumption that $\alpha < 1$ is a simple way to rule out these unappealing equilibria without introducing a cost of VC backing/monitoring, which introduces more complication and notation.

¹⁶ Here, by assuming that the VC raises exactly I , I am implicitly assuming that the VC retains the largest stake in the firm it can in the IPO while still funding the investment—it does not sell a larger stake and hold cash. If I allowed the VC to choose the size of the stake to keep at the IPO, it would behave this way endogenously. To be more specific, there would be a pooling equilibrium in which all types of the VC retain the largest possible stake; see Appendix A.26. (Although this equilibrium is not unique, I show that it survives a refinement akin to those that I impose on the equilibria in Propositions 1 and 2.)

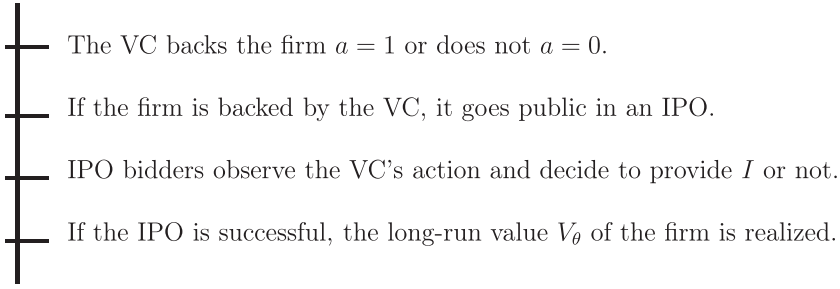


Figure 1. Sequence of moves.

obtaining the fixed fee. In other words, VCs can increase their compensation by improving their reputation as skilled investors. This allows them to increase their committed capital by retaining old investors and winning new ones.

To analyze the effects of these two components of VC compensation, I study the two extreme cases, in which the VC is (purely) profit-motivated or (purely) reputation-motivated. If the VC is profit-motivated, I denote its payoff by Π_{PM} . This case is standard; the VC's payoff is proportional to the value of the VC's long-term equity holding, that is, to the fraction $1 - \alpha$ of the firm that the VC holds after issuing α shares in the IPO:

$$\Pi_{\text{PM}} = \begin{cases} (1 - \alpha)V_\theta & \text{if IPO succeeds,} \\ 0 & \text{otherwise.} \end{cases} \quad (1)$$

If the VC is reputation-motivated, I denote its payoff by Π_{RM} . In this case, its payoff reflects the VC's reputation, which is equal to the market's belief that the VC is skilled, given all available information:¹⁷

$$\Pi_{\text{RM}} = \mathbb{P}[\text{skilled} \mid \text{public information}] = \mathbb{P}[s \mid \alpha, \iota V_\theta]. \quad (2)$$

This expression says that a VC's reputation consists of the market's belief that the VC is skilled based on all observables, namely, the VC's action α and potentially the long-run realized value of the firm V_θ . Note, however, that V_θ is observable only if the firm receives VC backing and successfully raises I in the IPO, or $\iota = 1$. Hence, the belief above is conditional on ιV_θ (and not V_θ).¹⁸

Notation. Below, I sometimes differentiate between the payoffs of the skilled VC and the unskilled VC with superscripts s and u . Further, I sometimes

¹⁷ Dasgupta and Prat (2006) show that these preferences arise endogenously from delegated investors' incentives to attract flows of capital from investors, that is, maximizing these flows is equivalent to maximizing the market's belief about skill.

¹⁸ The assumption that the market conditions its beliefs on both ιV_θ and α seems realistic. Anecdotal evidence from Grant Thornton's Global Equity Report (2014) suggests that VC investors do not simply look at returns, but also demand "multiple meetings, huge amounts of due diligence questionnaires," (p. 10) and ask management to "disclose more information [and] to share details of investment pipelines" (p. 5). That said, since ιV_θ is sufficient to infer α in equilibrium— $\iota V_\theta = 0$ if and only if $\alpha = 0$ (Propositions 1 and 2)—it is unlikely that relaxing this assumption would affect my results.

indicate how a VC's payoff depends on its action and the type of the firm in parentheses. For example, $\Pi_{\text{PM}}^s(a = 1, \theta = g)$ is the payoff of a skilled profit-motivated VC that backs ($a = 1$) a good firm ($\theta = g$).

E. Equilibrium Definition

The equilibrium concept is perfect Bayesian equilibrium. An equilibrium comprises the action $a \in \{0, 1\}$ for each type of VC as a function of its information and the decision to provide capital I for the IPO bidders. All players' actions must be sequentially rational and beliefs must be updated according to Bayes's rule on the equilibrium path.

F. Parameter Restrictions

I make two restrictions on parameters. The first says that the average long-term value of the firm is positive. The second says that the bad firm's long-term value is negative.

PARAMETER RESTRICTION 1:

$$\bar{V} := \varphi V_g + (1 - \varphi)V_b > 0. \quad (3)$$

PARAMETER RESTRICTION 2:

$$V_b < 0. \quad (4)$$

Parameter Restriction 2 captures the idea that the VC's costs of monitoring and investing outweigh the benefits of investing in a bad firm. For simplicity, I capture these costs in reduced form by implicitly folding them into V_θ , that is, V_θ represents the value of the firm net of these costs.¹⁹ In Section IV.E, I relax the assumption that $V_b < 0$ and show that if $V_b > 0$, the results are stronger. However, restricting attention to $V_b < 0$ in the baseline analysis helps me focus on the new economic mechanism in my paper.

II. Equilibrium Characterizations

In this section, I solve the model. The main results of the section are (i) a characterization of the equilibrium given that the VC is profit-motivated and (ii) a characterization of the equilibrium given that the VC is reputation-motivated. I begin by solving for the stake α required by the IPO bidders to provide capital to the VC-backed firm. This depends on their belief about the proportions of good and bad firms that receive VC backing.

¹⁹ In Section IV.F, I model these costs explicitly to show that this reduced-form way of modeling them does not affect my results.

A. IPO Success

In this subsection, I solve for the stake α required by the IPO bidders to provide capital to the VC-backed firm. Bidders are competitive, so they break even in equilibrium, that is, if they provide capital, then α solves

$$\alpha \mathbb{E}[V_\theta | \alpha = 1] = I. \quad (5)$$

Since, as discussed in Section I.B, it must be the case that $\alpha < 1$, the IPO succeeds if and only if the conditional expected value of the firm is greater than the cost of raising capital I , as summarized in the next lemma.

LEMMA 1: *The IPO succeeds if and only if*

$$\mathbb{E}[V_\theta | \alpha = 1] > I. \quad (6)$$

B. Equilibrium Characterization with a Profit-Motivated VC

In this subsection, I first characterize the equilibrium in which firms successfully go public with a profit-motivated VC. I refer to this as the *profit-motivation equilibrium*. (In the Appendix, I show that this is the unique equilibrium that survives a refinement akin to the Intuitive Criterion, which says that bidders must believe that deviations come from the type that has the most to gain.) I then describe the case in which the market breaks down, that is, in which there is no equilibrium in which the VC backs the firm.

PROPOSITION 1: *Suppose the VC is profit-motivated. If*

$$\varphi \gamma \text{NPV}_g + (1 - \gamma) \overline{\text{NPV}} > 0, \quad (7)$$

then there is an equilibrium in which the positively informed VC and the unskilled VC back the firm and the negatively informed VC does not. This is the unique equilibrium in which the IPO is successful. Further, equilibria in which the IPO is not successful are Pareto-dominated. They are also not robust to a refinement formalized in the proof of the proposition.

In the profit-motivation equilibrium above, the positively informed VC backs the firm but the negatively informed VC does not. This is because the negatively informed VC knows that the long-term value of the bad firm is negative, $V_b < 0$ (by Parameter Restriction 2), so it will always lose if it backs the firm. However, the unskilled VC knows that the long-term value of the average firm is positive, $\overline{V} > 0$ (by Parameter Restriction 1), so it gains on average if it backs the firm, even if the average *net* present value is negative, or $\overline{\text{NPV}} < 0$. The unskilled VC cares about the PV and not the NPV because there is a cross-subsidy from the positively informed VC to the unskilled VC at the time of the IPO. In other words, the unskilled VC has an incentive to overinvest because it can sell overpriced shares in the IPO. This overinvestment reduces the average quality of VC-backed firms. Indeed, the quality reduction from overinvestment may be

so severe that it causes the IPO market to break down entirely, as I describe in the following corollary.

COROLLARY 1: *Suppose the VC is profit-motivated. If*

$$\varphi\gamma\text{NPV}_g + (1 - \gamma)\overline{\text{NPV}} \leq 0, \tag{8}$$

then there is no equilibrium in which the VC backs the firm.

Observe that the market breaks down even though the VC may be skilled and may have information about the underlying quality of the firm. This is because the unskilled VC pools with the skilled VC, which prevents the skilled VC’s action from transmitting information to the IPO bidders. This, in turn, prevents the bidders from providing the necessary capital at the time of the IPO.

C. Equilibrium Characterization with a Reputation-Motivated VC

In this subsection, I first characterize the equilibrium in which firms successfully IPO with a reputation-motivated VC. I refer to this as the *reputation-motivation equilibrium*. (In the Appendix, I show that this is the unique equilibrium that survives a refinement somewhat similar to that imposed above on the profit-motivation equilibrium, in that it rules out “unreasonable” off-equilibrium beliefs.) I then describe the case in which the market breaks down, that is, in which there is no equilibrium in which the IPO is successful.

PROPOSITION 2: *Suppose the VC is reputation-motivated. If either $\gamma \geq \varphi/(1 - \varphi + \varphi^2)$ or*

$$\varphi\gamma\text{NPV}_g + (\varphi\gamma(1 - \varphi) - \gamma + \varphi)\overline{\text{NPV}} > 0, \tag{9}$$

then there is an equilibrium in which the VC behaves as follows: if it is positively informed, it backs the firm; if it is negatively informed, it does not back the firm; and if it is unskilled, it backs the firm with probability μ^ , where*

$$\mu^* = \max \left\{ 0, \frac{\varphi\gamma(1 - \varphi) - \gamma + \varphi}{1 - \gamma} \right\}. \tag{10}$$

This is the unique equilibrium that satisfies a refinement formalized in the proof of the proposition.

In the reputation-motivation equilibrium above, the skilled VC “follows its signal” to show off its information—it backs the firm when it is positively informed and does not when it is negatively informed. In contrast, the unskilled VC has an incentive not to back the firm, to hide its lack of information. Indeed, if the VC does not back the firm, then the firm’s type is not revealed and as a result, the market can never infer that the VC is, in fact, unskilled. In other words, when the VC does not back the firm, an inference channel is shut: the market bases its inference only on the VC’s action $a = 0$, since it cannot use the value V_θ of the firm to update its beliefs. Thus, by playing $a = 0$, the unskilled VC can always pool with the skilled (negatively informed) VC. If, instead, the

firm's type were revealed regardless of whether it received backing from the VC, then the unskilled VC would back the firm more often—playing $a = 0$ would not allow it to hide. This is summarized in the next lemma.

LEMMA 2: *Consider the benchmark in which the firm's type is always revealed, that is, the market learns the firm's type even if $i = 0$. The unskilled VC backs the firm less frequently in the reputation-motivation equilibrium in Proposition 2 than in this benchmark.*

So far, I have explained why the unskilled VC would choose not to back the firm—doing so allows it to pool with the skilled negatively informed VC. But why does the unskilled VC not always play $a = 0$? Because if it did, then the market would believe that only the skilled VC was backing firms. So, if the unskilled VC backed a firm that turned out to be good, the market would believe that it was skilled for sure. This high upside payoff from backing the firm and being right can compensate for the downside of backing it and being wrong (and hence revealing itself as unskilled). This leads to mixing in equilibrium, where the mixing probability varies as a function of the proportions of skilled VCs and good firms, as described in the next lemma.

LEMMA 3: *Given the equilibrium in Proposition 2, the probability μ^* with which the unskilled reputation-motivated VC backs the firm is increasing in the proportion of good firms φ and decreasing in the proportion of skilled VCs γ .*

Intuitively, the unskilled VC is more likely to back a firm that is likely to be good, since it is likely to be right. Hence, μ^* is higher when φ is higher. However, the unskilled VC is less likely to back a firm when other VCs are likely to be skilled, since it can pool with them by choosing not to back the firm. Hence, μ^* is lower when γ is higher.²⁰

Reputation motivation induces the unskilled VC not to back the firm. However, there may still be too much VC backing relative to first-best in the reputation-motivation equilibrium—the unskilled VC may still back a firm with negative expected NPV. As a result, market breakdowns can still occur, as I describe in the following corollary.

COROLLARY 2: *Suppose the VC is reputation-motivated. If $\gamma < \varphi/(1 - \varphi + \varphi^2)$ and*

$$\varphi\gamma\text{NPV}_g + (\varphi\gamma(1 - \varphi) - \gamma + \varphi)\overline{\text{NPV}} \leq 0, \quad (11)$$

then there is no equilibrium in which the VC backs the firm.

²⁰ The market's ex ante belief that the VC is skilled is γ . It can be interpreted as the ex ante strength of the VC's reputation: the higher is γ , the better the market expects the VC to be. With this interpretation, Lemma 3 implies that the stronger the VC's reputation is, the less frequently it backs—in some sense, the stronger its reputation is, the more reputation-motivated it acts.

III. The Costs and Benefits of Reputation Motivation

In this section, I compare the profit-motivation equilibrium and the reputation-motivation equilibrium. I show that reputation motivation can be beneficial in the following three senses.

- (i) If the IPO is successful, the value of the firm at IPO is higher when the VC is reputation-motivated than when it is profit-motivated.
- (ii) Market breakdowns are less likely when the VC is reputation-motivated than when it is profit-motivated.
- (iii) If the expected NPV is negative, total output or “productive efficiency” is higher when the VC is reputation-motivated than when it is profit-motivated.

A. Reputation Motivation Prevents Market Breakdowns

In this subsection, I compare the likelihood of a market breakdown in the profit-motivation equilibrium with the likelihood of a market breakdown in the reputation-motivation equilibrium. I find that reputation motivation makes market breakdowns less likely. This follows from the fact that the unskilled reputation-motivated VC is conservative—it invests less than the unskilled profit-motivated VC—as summarized in the next lemma.

LEMMA 4: *Absent market breakdowns, the unskilled reputation-motivated VC backs the firm less frequently than the unskilled profit-motivated VC.*

This leads to the next result that the value of the firm at the time of the IPO is higher when the VC is reputation-motivated.

LEMMA 5: *The value of the firm at the time of the IPO is higher when the VC is reputation-motivated than when it is profit-motivated:*

$$\mathbb{E}[V_\theta | \alpha = 1]_{\text{IRM}} > \mathbb{E}[V_\theta | \alpha = 1]_{\text{PM}}. \quad (12)$$

The value premium associated with reputation motivation is the result of the behavior of the unskilled VC. Because the firms that get backing and go to IPO are backed by either a positively informed VC or an unskilled VC, the less frequently the unskilled VC backs the firm, the more likely it is that a firm going public is backed by a positively informed VC, and therefore the more likely it is to be a good firm. Hence, firms backed by reputation-motivated VCs have higher expected values than those backed by profit-motivated VCs. These higher firm values lead to fewer market breakdowns, as stated in the next proposition.

PROPOSITION 3: *Market breakdowns are less likely with a reputation-motivated VC, in the sense that there is a market breakdown with a profit-motivated VC whenever there is a market breakdown with a reputation-motivated VC but not the other way around.*

This result underscores an important positive role that reputation motivation can play: it alleviates information frictions that prevent firms from being able to raise capital and make positive-NPV investments. Since unskilled reputation-motivated VCs are conservative, the firm's expected value at the time of the IPO is high, as Lemma 5 underscores. Thus, in the reputation-motivation equilibrium, VC backing has a certification effect. This certification effect induces IPO bidders to provide capital, thereby preventing market breakdowns.

B. Productive Efficiency

In this subsection, I compare productive efficiency in the profit-motivation equilibrium with productive efficiency in the reputation-motivation equilibrium.

I begin by giving a formal definition of productive efficiency.

DEFINITION 1: *Productive efficiency is total output minus total input, or*

$$W := \iota(V_\theta - I). \quad (13)$$

New output is measured by W because the NPV $V_\theta - I$ is realized only if I is successfully raised in the IPO, or $\iota = 1$.²¹

I now can compare W in the profit-motivation equilibrium with W in the reputation-motivation equilibrium.

PROPOSITION 4: *Productive efficiency is higher in the reputation-motivation equilibrium than in the profit-motivation equilibrium if and only if the expected NPV is negative, $\overline{\text{NPV}} < 0$.*

This result points to another benefit of reputation motivation: with reputation motivation, the VC filters out bad firms, increasing the average quality of firms that get backing. If the average NPV of the firm is negative, then this increases productive efficiency. Further, since VCs capture all of the rent in this model (IPO bidders break even), this increase in productive efficiency corresponds to an increase in the VC's expected profits: if the average NPV is negative, then a reputation-motivated VC makes higher profits on average than a profit-motivated VC. Why does a VC that does not care about making profits make more than one that cares only about profits? Because profit-maximizing behavior has a negative effect on IPO prices, akin to a negative pecuniary externality. To maximize its own profits, an unskilled profit-maximizing VC backs all negative average NPV firms. Understanding this, IPO bidders charge all VCs a higher price, passing through the costs of the negative NPV investments and lowering a VC's ex ante expected profits.

However, if the average NPV of the firm is positive, reputation motivation decreases productive efficiency. In this case, it is better to have average NPV

²¹ I think of W as a natural measure of efficiency—it basically coincides with GDP. However, it is worth noting that this is not a transferable utility model, and reputation-motivated VCs have preferences over not only consumption but also reputation, so there is no perfect cardinal measure of welfare here.

firms backed indiscriminately (as in the profit-motivation equilibrium) than to undertake only a selection of better firms (as in the reputation-motivation equilibrium). Regardless of the sign of the average NPV, this difference in productive efficiency is driven by the behavior of the unskilled VC. Indeed, the more unskilled VCs there are, the larger is the absolute difference.

COROLLARY 3: *The absolute difference between productive efficiency with a reputation-motivated VC and with a profit-motivated VC is decreasing in the proportion of skilled VCs, that is,*

$$\frac{\partial}{\partial \gamma} |\mathbb{E}[W_{RM}] - \mathbb{E}[W_{PM}]| \leq 0. \tag{14}$$

Proposition 4 says that reputation motivation helps most when the average NPV is negative. But in this negative average NPV case, does it help more when there are a lot of fairly good investment opportunities—high φ , but low V_g —or when there are relatively few good investment opportunities—low φ , but high V_g ?

COROLLARY 4: *Suppose $\overline{NPV} < 0$. For a given average NPV, the benefits of reputation motivation for productive efficiency are decreasing in the proportion of good firms, that is, if $\overline{NPV} < 0$, then*

$$\frac{\partial}{\partial \varphi} \Big|_{\overline{NPV} = \text{const.}} (\mathbb{E}[W_{RM}] - \mathbb{E}[W_{PM}]) \leq 0. \tag{15}$$

This result says that reputation motivation helps the most in the environment in which VCs operate in practice, that is, in which most deals involve losing a little bit but a few deals (Google’s and Facebook’s) involve making a lot.

IV. Extensions and Robustness

In this section, I extend the baseline model in several ways and I check the robustness of the results above.

- (i) I add “assets in place,” so that the market may learn the firm’s type even if it does not get VC backing.
- (ii) I assume that the VC sells its equity stake, instead of retaining it, at the time of the IPO.
- (iii) I add asymmetric information among IPO bidders to generate an IPO discount.
- (iv) I consider an alternative specification of the reputation-motivation component of the VC’s preferences to capture a nonlinear flow-performance relationship.
- (v) I consider the case in which $V_b > 0$.
- (vi) I consider the case in which the VC pays a cost to back the firm.
- (vii) I relax the assumption that the unskilled VC is completely uninformed, allowing it to observe a noisy signal about the quality of the firm.

A. Assets in Place

In the baseline model, I assume that if the firm does not receive backing, its value is zero. This assumption determines the VC's behavior in the reputation-motivation equilibrium: because both the good firm and the bad firm have zero value when the VC does not back them, the market's ability to update its beliefs about a VC that does not back a firm is limited. In this subsection, I extend the model to include "assets in place," that is, firm value is not necessarily zero if it does not receive backing from the VC. If the firm receives backing from the VC and goes IPO, it undertakes an additional "expansion" project. The correlation, q , between the assets in place and the expansion project captures the extent to which the VC can prevent the market from learning by not backing the firm—if $q = 1$, the market learns the type from the value of the assets in place regardless of whether the VC backs the firm. I show that the reputation-motivated VC's behavior is qualitatively the same as it is in the baseline model. I then argue that increasing q attenuates the benefits of reputation motivation for market breakdowns (Proposition 3) and productive efficiency (Proposition 4).

Here, I assume that if the firm is backed, V_θ is the overall value of the firm, that is, the sum of the value of the assets in place and the value of the new project. If the firm is not backed, it keeps its assets in place with probability q , while with probability $1 - q$, it is unable to continue and the firm's value is zero. Specifically, the firm with quality θ has value χv_θ if it does not receive backing, where $v_\theta < V_\theta$ is the value of the assets in place if the firm continues and χ is an independent indicator random variable indicating whether the firm continues,

$$\chi = \begin{cases} 1 & \text{with prob. } q, \\ 0 & \text{with prob. } 1 - q. \end{cases} \quad (16)$$

The first result of this subsection is a characterization of the equilibrium, which is analogous to the reputation-motivation equilibrium in Proposition 2.

LEMMA 6: *Suppose the VC is reputation-motivated. The unskilled VC backs the firm with probability μ^q defined by equation (A.71) in the proof. If*

$$\varphi\gamma\text{NPV}_g + (1 - \gamma)\mu^q \overline{\text{NPV}} > 0, \quad (17)$$

then there is an equilibrium in which a VC behaves as follows: if it is positively informed, it backs the firm; if it is negatively informed, it does not back the firm; and if it is unskilled, it backs the firm with probability μ^q .

As in the reputation-motivation equilibrium, the positively informed VC backs the firm, the negatively informed VC does not back the firm, and the unskilled VC randomizes between backing and not backing. The parameter q captures the extent to which the market relies on the VC backing the firm to make an inference about the firm's type. Indeed, if $q = 0$, the value of the assets in place is always zero, so the equilibrium coincides with the reputation-motivation equilibrium in Proposition 2. In contrast, if $q = 1$, the assets in place are perfectly correlated with the value of the firm, so the model coincides

with the benchmark in Lemma 2 in which the VC's type is always revealed. Because there is no asymmetric learning in this case, not backing the firm does not help the unskilled VC to hide its type. The next lemma says that varying q interpolates between the baseline model and the benchmark model in Lemma 2.

LEMMA 7: *Consider the model with assets in place and a reputation-motivated VC. If $q = 0$, the equilibrium is the reputation-motivation equilibrium of the baseline model in Proposition 2. If $q = 1$, the equilibrium is the reputation-motivation equilibrium of the benchmark model in Lemma 2. For $q \in (0, 1)$, the unskilled VC backs the firm with probability μ^q , where μ^q is a continuous increasing function of q . Thus, increasing the correlation between the assets in place and the expansion project monotonically interpolates between the reputation-motivation equilibrium and the benchmark equilibrium.*

This result implies that increasing q attenuates the effects of reputation motivation on market breakdowns (Proposition 3) and on productive efficiency (Proposition 4).

PROPOSITION 5: *If the firm has assets in place, the results in Section III on the benefits of reputation motivation are attenuated as follows:*

- (IPO VALUE) *The higher is q , the lower is the value premium associated with reputation motivation. That is, the difference $\mathbb{E}[V_\theta | a = 1]_{\text{RM}} - \mathbb{E}[V_\theta | a = 1]_{\text{PM}}$ is decreasing in q .*
- (MARKET BREAKDOWNS) *The higher is q , the less reputation motivation helps in preventing market breakdowns.*
- (PRODUCTIVE EFFICIENCY) *The higher is q , the less reputation motivation affects productive efficiency, that is, the absolute difference $|\mathbb{E}[W_{\text{RM}}] - \mathbb{E}[W_{\text{PM}}]|$ is decreasing in q .*

B. VC Sells at the Time of the IPO

In the baseline model, I assume that the VC retains its equity stake until the final value of the firm is realized. In this subsection, I consider the model in which the VC exits at the time of the IPO. The main difference from the results in the baseline model is that, in equilibrium, the negatively informed profit-motivated VC backs the firm. This amplifies my results on the benefits of reputation motivation in Section III above.

Consider the variation of the model in which the VC exits at the IPO, selling its stake at the market price. Here, the reputation-motivation component of the payoff is unaffected, since it does not depend on profits, but only on the market beliefs. In contrast, the profit-motivation component of the payoff is changed. It is now given by the market value of the VC's equity stake, rather than the private value to the VC. If the IPO succeeds, the VC's payoff is equal to the

expected value of the long-term assets given VC-backing, net of the investment cost:

$$\Pi_{PM} = \begin{cases} \mathbb{E}[V_\theta | a = 1] - I & \text{if the IPO succeeds,} \\ 0 & \text{otherwise.} \end{cases} \quad (18)$$

Observe that this payoff does not depend on the VC's type, but only on the value that the market assigns to the firm at the time of the IPO. Thus, the positively informed VC, the negatively informed VC, and the unskilled VC all make the same profit. This implies that either no type of VC backs the firm or all do, including even the negatively informed VC. The next result characterizes the equilibrium.

LEMMA 8: *Suppose the VC is profit-motivated. If $\overline{NPV} > 0$, then there is an equilibrium in which the positively informed VC, the negatively informed VC, and the unskilled VC back the firm.*

Since even the negatively informed profit-motivated VC backs the firm in this equilibrium, the overinvestment problem in the profit-motivation equilibrium is especially severe. Thus, the results on the benefits of reputation motivation in Section III are amplified.

PROPOSITION 6: *If the VC sells at the IPO, this amplifies the results in Section III on the benefits of reputation motivation as follows:*

- (IPO VALUE) *The value of the firm at the time of IPO is higher if the VC retains its stake than if it exits,*

$$\mathbb{E}[V_\theta | a = 1]_{|PM, \text{ retain}} > \mathbb{E}[V_\theta | a = 1]_{|PM, \text{ exit}}. \quad (19)$$

Thus, the difference between the value of the firm with reputation motivation and the value of the firm with profit motivation is even higher than in the baseline model (Lemma 5).

- (MARKET BREAKDOWNS) *If $\overline{NPV} < 0$, there is no profit-motivation equilibrium in which the VC backs the firm and the IPO is successful. Thus, reputation motivation helps prevent market breakdowns for a larger range of parameters than in the baseline model (Proposition 3).*
- (PRODUCTIVE EFFICIENCY) *If*

$$\overline{NPV} < \frac{\varphi\gamma NPV_g}{1 - (1 - \gamma)\mu^*}, \quad (20)$$

productive efficiency is higher in the reputation-motivation equilibrium than in the profit-motivation equilibrium. Thus, reputation motivation increases productive efficiency for a larger range of parameters than in the baseline model (Proposition 4).

C. IPO Discount

In the baseline model, I abstract from an important feature of real-world IPOs: the IPO discount. To capture this discount, I extend the model to include adverse selection at the IPO. Following the standard model of Rock (1986), in this case, there is a winners' curse: competing with informed bidders, uninformed bidders get fewer shares in good firms than in bad firms. Specifically, I assume that they get all of the shares in a bad firm, but only the fraction $1 - \delta$ of the shares in a good firm. Hence, the issuer must sell at a discounted price to induce uninformed IPO bidders to bid.

In this setup, as in Rock (1986), the IPO price p (of the whole firm) is set to ensure that the uninformed bidders break even,²² that is,

$$\mathbb{E}[(1 - \mathbb{1}_{\{\theta=g\}}\delta)(V_\theta - p) | \alpha = 1] = 0. \tag{21}$$

Hence, the IPO price is given by

$$p = \frac{\mathbb{E}[(1 - \mathbb{1}_{\{\theta=g\}}\delta)V_\theta | \alpha = 1]}{\mathbb{E}[1 - \mathbb{1}_{\{\theta=g\}}\delta | \alpha = 1]}. \tag{22}$$

I can now find the IPO price in the profit-motivation and reputation-motivation equilibria and show the following.

LEMMA 9: *The IPO price p is higher when the VC is reputation-motivated than when it is profit-motivated,*

$$p_{RM} > p_{PM}.$$

Now, the IPO succeeds if and only if the firm can raise I . Since the VC can sell at most and only the whole firm, which is worth p , the IPO succeeds if and only if $p \geq I$. Thus, it follows from Lemma 9 that reputation motivation can help prevent market breakdowns and hence improve welfare.

PROPOSITION 7: *Suppose that δ is the proportion of the firm that goes to informed bidders at the IPO. Productive efficiency is higher in the reputation-motivation equilibrium than in the profit-motivation equilibrium whenever*

$$\overline{\text{NPV}} < \frac{(\delta - \gamma)\varphi}{1 - \gamma} \text{NPV}_g. \tag{23}$$

Indeed, the larger the IPO discount is, that is, the larger δ is, the more likely it is that reputation motivation enhances efficiency (see Proposition 4). Here, it enhances efficiency even for some positive NPV firms. By not backing firms with low but positive NPV—something that would typically be inefficient—reputation-motivated VCs have a certification effect strong enough to overcome adverse-selection-induced market breakdowns.

²²This relies on the assumption that informed bidders have limited capital and hence uninformed bidders are “marginal,” that is, the price is set to induce the uninformed bidders to participate in the IPO.

D. Nonlinear Flow-Performance Relationship

In the baseline model, I assume that the reputation-motivation component of the VC's payoff Π_{RM} is linear in the market's belief about the VC's skill. Empirically, however, there is a nonlinear flow-performance relationship in asset management. Chevalier and Ellison (1999) find that this relationship is convex for mutual funds, whereas evidence in Crain (2016) and Kaplan and Schoar (2005) suggests that it is concave for venture capital and private equity, respectively. In this subsection, I show that a concave flow-performance relationship amplifies the results in Section III on the benefits of reputation motivation. However, convexity typically induces risk-taking and, as a result, one might think that a convex flow-performance relationship would overturn these results, leading reputation-motivated VCs to back firms more frequently. I show that the first part of this intuition is right, but the second is not: a convex flow-performance relationship induces the VC to back firms more frequently, but it does not overturn the qualitative differences between profit motivation and reputation motivation.

Consider the variation of the model in which the reputation-motivation component of the VC's payoff is proportional to the market's posterior belief about its type raised to the power κ :

$$\Pi_{RM} = (\mathbb{P}[\text{skilled} \mid \text{public information}])^\kappa = (\mathbb{P}[s \mid a, \iota V_\theta])^\kappa. \tag{24}$$

This captures the convex flow-performance relationship for $\kappa > 1$, since in this case, it is a convex function of the market's belief; likewise, it captures a concave flow-performance relationship for $\kappa \in (0, 1)$.

This specification of Π_{RM} does not affect the profit-motivation equilibrium, which depends only on Π_{PM} . The main result of this section is that it does affect the reputation-motivation equilibrium. It induces the unskilled VC to back the firm more frequently than in the baseline model if and only if the payoff is convex in the posterior ($\kappa > 1$). However, it still backs the firm less frequently than in the profit-motivation equilibrium for all $\kappa > 0$.

PROPOSITION 8: *Suppose that the VC is reputation-motivated with payoff given by equation (24). If $\gamma \geq \frac{\varphi^{1/\kappa}}{1-\varphi+\varphi^{1+1/\kappa}}$ or*

$$\varphi\gamma\text{NPV}_g + \frac{\varphi^{1/\kappa} - \gamma(1 - \varphi + \varphi^{1+1/\kappa})}{1 - \varphi + \varphi^{1+1/\kappa}}\overline{\text{NPV}} > 0, \tag{25}$$

then there is an equilibrium in which the VC behaves as follows. If it is positively informed, it backs the firm; if it is negatively informed, it does not back the firm; and if it is unskilled, it backs the firm with probability

$$\mu^\kappa = \max \left\{ 0, \frac{\gamma\varphi(1 - \varphi^{1/\kappa}) - \gamma + \varphi^{1/\kappa}}{(1 - \gamma)(1 - \varphi + \varphi^{1/\kappa})} \right\}. \tag{26}$$

The unskilled VC backs the firm more frequently than in the baseline model if and only if the flow-performance relationship is convex, that is, $\mu^k > \mu^$ in equation (10) if and only if $\kappa > 1$.*

E. V_b Positive

In the baseline model, I assume that the final value of the bad firm is negative, $V_b < 0$. This reflects the realistic idea that bad VC investments are likely to fail completely and have negative value net of the VC's costs of monitoring and capital investment. However, this assumption is not necessary for my results. In this subsection, I consider the model in which $V_b > 0$. The VC's equilibrium strategies in this setup coincide with those in the extension in which the VC exits at the time of the IPO (Section IV.B). The only difference from the baseline model is that the negatively informed profit-motivated VC backs the firm. As I show in Section IV.B, this amplifies my results on the benefits of reputation motivation in Subsection III.

Consider the variation of the model in which $V_b > 0$. Here, the reputation-motivation equilibrium is unaffected, since reputation-motivated VCs care only about the market's beliefs and not profits. But the profit-motivation equilibrium changes: the VC backs the firm whenever the expectation of its profit (as defined in equation (1)) is positive. Since $V_b > 0$, this is now the case whenever the IPO is successful, or $\alpha \in (0, 1)$. As in Section IV.B, this implies that either no type of VC backs the firm or all do, including even the negatively informed VC.

LEMMA 10: *Suppose the VC is profit motivated. If $\overline{\text{NPV}} > 0$, then there is an equilibrium in which the positively informed VC, the negatively informed VC, and the unskilled VC back the firm.*

As in Section IV.B, the overinvestment problem in the profit-motivation equilibrium is even more severe here than in the baseline model, amplifying the baseline results on the benefits of reputation motivation. In fact, Proposition 6 holds here.

F. Costs of VC Backing

In the baseline model, I assume that the VC gets profit $(1 - \alpha)V_\theta$ if it backs the firm and zero if it does not back the firm; in doing so, I implicitly assume that the cost of any capital c that the VC provides upfront is embedded in the final payoff V_θ (see the discussion in Section I.F). Normalizing c to zero simplifies the analysis, but it is not immediate that it is without loss of generality. Here, I model this explicitly and show that it is.

Consider the variation of the model in which the VC pays a cost c to back the firm. Here, the reputation-motivation component of the payoff is unaf-

fected, since it depends on market beliefs, not on profits. In contrast, the profit-motivation component changes. If the VC backs the firm, it gets

$$\Pi_{PM} = \begin{cases} (1 - \alpha)V_\theta - c & \text{if IPO succeeds,} \\ -c & \text{otherwise.} \end{cases} \quad (27)$$

If the VC does not back the firm, it gets $\Pi_{PM} = 0$.

I show that the profit-motivation equilibrium (Proposition 1) and the reputation-motivation equilibrium (Proposition 2) in the baseline model are the equilibria of the corresponding extended model in which the VC has fixed cost c of backing the firm, under appropriately modified conditions (in particular, I do not require that $V_b < 0$, since $c > 0$ captures the VC's cost of backing the firm). This is summarized in the proposition below.

LEMMA 11: *Suppose*

$$\frac{\varphi\gamma\text{NPV}_g + (1 - \gamma)\overline{\text{NPV}}}{\varphi\gamma V_g + (1 - \gamma)\overline{V}} \overline{V} \geq c \geq \frac{\varphi\gamma\text{NPV}_g + (1 - \gamma)\overline{\text{NPV}}}{\varphi\gamma V_g + (1 - \gamma)\overline{V}} V_b. \quad (28)$$

If the IPO succeeds, the profit-motivation equilibrium strategies coincide with those in Proposition 1 and the reputation-motivation equilibrium strategies coincide with those in Proposition 2.

G. Partially Informed Unskilled VCs

In this section, I relax the assumption that the unskilled VC is completely uninformed. Here, I assume that while the skilled VC is perfectly informed, as in the baseline model, the unskilled VC gets a noisy (private) signal about the quality of the firm. I first show that unskilled VCs follow threshold strategies, backing firms only if their signal is above a threshold. I then show that the unskilled reputation-motivated VC applies a higher threshold than the unskilled profit-motivated VC, that is, it is conservative. This extension supports the robustness of my results and facilitates an interpretation of VCs' behavior in terms of the hurdle rates they apply to investments: reputation-motivated VCs apply higher hurdle rates than profit-motivated VCs, a result that seems to be in line with empirical evidence, as discussed in the introduction.

Specifically, I assume that the unskilled VC observes a signal σ , drawn from a uniform distribution $\sigma \sim U[\underline{\sigma}, 1]$, such that $\mathbb{P}[\theta = g | \sigma] = \sigma$. Using the law of iterated expectations, we can see that this implies that the proportion φ of good firms must be the midpoint of the support of this distribution,

$$\varphi V_g + (1 - \varphi)V_b \equiv \mathbb{E}[V_\theta] = \mathbb{E}[\sigma]V_g + (1 - \mathbb{E}[\sigma])V_b, \quad (29)$$

and hence $\varphi = \mathbb{E}[\sigma] = \frac{\underline{\sigma} + 1}{2}$, since σ is uniform on $[\underline{\sigma}, 1]$. Finally, as in the baseline model, I assume that the present value of a firm is always positive from the point of view of an unskilled VC, that is, I replace Parameter Restriction 1 with the following restriction.

PARAMETER RESTRICTION 1'

$$\underline{\sigma}V_g + (1 - \underline{\sigma})V_b > 0. \tag{30}$$

Everything else is as in the baseline model.

With this setup, I can show that the unskilled profit-motivated VC always backs the firm, exactly as in the baseline model, and the unskilled reputation-motivated VC backs the firm only if it observes a signal σ above a threshold $\hat{\sigma}_{RM}$.

PROPOSITION 9: *In both the profit-motivation and reputation-motivation equilibria, the skilled positively informed VC backs the firm and the skilled negatively informed VC does not. In the profit-motivation equilibrium, the unskilled VC backs the firm no matter its signal, whereas in the reputation-motivation equilibrium, the unskilled VC backs the firm whenever its signal is above the threshold $\hat{\sigma}_{RM}$ defined in equation (A.131) in the Appendix. This threshold is always strictly greater than $\underline{\sigma}$.*

This result implies that, as in the baseline model, the unskilled profit-motivated VC always backs the firm, whereas the unskilled reputation-motivated VC backs it with probability less than one. Specifically, both follow threshold strategies: the unskilled profit-motivated VC applies the threshold $\underline{\sigma}$, backing all of the time, whereas the unskilled reputation-motivated VC applies a higher threshold, backing only when $\sigma \geq \hat{\sigma}_{RM}$. These thresholds correspond exactly to the hurdle rates that VCs apply to investments—they are the rates of return that VCs require to back investments. Thus, the result implies that reputation-motivated VCs apply higher hurdle rates.²³ Observe that there is a range of signals $(\underline{\sigma}, \hat{\sigma}_{RM})$ over which the unskilled reputation-motivated VC could increase its profit by backing firms. However, as emphasized above, this behavior can indirectly generate higher equilibrium profits for the reputation-motivated VC by preventing market breakdowns. Moreover, the result implies that the more reputable the unskilled reputation-motivated VC is, the higher is the hurdle rate it applies.

COROLLARY 5: *The threshold that a reputation-motivated VC applies to investments increases in its reputation, that is,*

$$\frac{\partial \hat{\sigma}_{RM}}{\partial \gamma} > 0. \tag{31}$$

This corollary is analogous to Lemma 3: the unskilled VC is less likely to back a firm (i.e., it applies a higher threshold) when the market believes that the VC is likely to be skilled (i.e., when the market believes that it is reputable).

²³ Two other theoretical papers emphasize VCs' high hurdle rates. Jovanovic and Szentes (2013) show that VCs' higher opportunity costs lead them to apply higher hurdle rates on investments, raising the IPO values of VC-backed firms above those of other firms. Donaldson, Piacentino, and Thakor (2019) show that they can help to mitigate soft-budget constraint problems. Relatedly, Inderst, Mueller, and Münnich (2007) show that VCs' shallow pockets overcome entrepreneurial incentive problems by creating a tournament among firms competing for VC backing.

The intuition is the same as that in Lemma 3: when the market believes that a VC is likely to be skilled, the unskilled VC can pool by choosing not to back the firm.

V. Conclusion

In this paper I examine the effects of the reputation motivation of delegated primary market investors, namely, venture capitalists. In contrast to the findings of the literature on delegated investment in the secondary market, I find that reputation motivation can improve efficiency. In particular, VCs can mitigate asymmetric-information frictions in the IPO market, allowing good firms to raise capital due to a certification effect of VC backing. This paper thus uncovers a positive side of delegated investors' reputation motivation that is at work in the primary market.

Initial submission: June 3, 2016; Accepted: October 11, 2017
 Editors: Bruno Biais, Michael R. Roberts, and Kenneth J. Singleton

Appendix A: Proofs

A.1. Proof of Lemma 1

Whenever the IPO is successful,

$$\alpha = \frac{I}{\mathbb{E}[V_\theta | a = 1]} \quad (\text{A.1})$$

by equation (5). Thus, $\alpha \in (0, 1)$ if and only if $\mathbb{E}[V_\theta | a = 1] > I$. □

A.2. Proof of Proposition 1

First, I verify that the outcome described in the proposition is an equilibrium (i.e., that everyone's strategy is a best response). Second, I show that it is the unique equilibrium in which the IPO succeeds. Third, I show that it Pareto-dominates equilibria in which the IPO does not succeed. Finally, I show that it is the unique equilibrium that survives a refinement akin to the intuitive criterion.

A.2.1. Verification of the Equilibrium

In this proof, I proceed by the usual conjecture-and-verify method of finding perfect Bayesian equilibria. I conjecture an equilibrium in which (i) the positively informed VC plays $a = 1$, (ii) the uninformed VC plays $a = 1$, and (iii)

the negatively informed VC plays $a = 0$. Thus, the expected value of the firm conditional on $a = 1$ is

$$\mathbb{E}[V_\theta | a = 1] = \frac{\varphi\gamma V_g + (1 - \gamma)\bar{V}}{\varphi\gamma + 1 - \gamma}. \tag{A.2}$$

Bidders. By Lemma 1, the IPO succeeds if

$$\frac{\varphi\gamma V_g + (1 - \gamma)\bar{V}}{\varphi\gamma + 1 - \gamma} > I. \tag{A.3}$$

This is equivalent to condition (7) in the proposition.

Skilled VC. If the VC is skilled, then its payoff is $(1 - \alpha)V_\theta$. Since $0 < \alpha < 1$ and $V_g > 0 > V_b$, the negatively informed VC prefers not to back the firm and the positively informed VC prefers to back the firm.

Unskilled VC. If the VC is unskilled, then its payoff is $(1 - \alpha)\bar{V}$. Since $0 < \alpha < 1$ and $\bar{V} > 0$, the unskilled VC prefers to back the firm. \square

A.2.2. Uniqueness Given IPO Success

The VC’s best responses above imply that whenever the IPO is successful, that is, $0 < \alpha < 1$, the positively informed VC and the unskilled VC back the firm and the negatively informed VC does not. Thus, the equilibrium is the unique equilibrium in which the IPO succeeds. \square

A.2.3. Pareto-Dominance if the IPO Is Unsuccessful

There are also equilibria in which the IPO is unsuccessful (e.g., if a VC that backs the firm is believed to be negatively informed, then it is a best response for no VC to back the firm). These equilibria are Pareto-dominated by the equilibrium stated in the proposition. This is because in these equilibria, all types of VC get zero, whereas in the equilibrium above, the positively informed VC and the unskilled VC get positive expected payoffs and the negatively informed VC gets zero. (Bidders break even in both types of equilibrium.) \square

A.2.4. Equilibrium Selection in the Profit-Motivation Equilibrium

Here, I argue further that the equilibrium in which the positively informed and the unskilled VC back the firm is the “right” equilibrium. I show that, in addition to being Pareto-dominated, the equilibria in which the IPO is unsuccessful are not robust to a belief-based refinement akin to the Intuitive Criterion.

I impose the following restriction on bidders’ out-of-equilibrium beliefs: the bidders believe that the deviations come from the type that has the most to gain, in line with Banks and Sobel’s (1987) D1 criterion.²⁴ Now consider an

²⁴ Specifically, in this model, the D1 criterion would say that the bidders should believe that deviations come from the positively informed VC whenever the following two conditions are satisfied:

equilibrium in which no type of VC backs the firm. The restriction on beliefs implies that bidders believe that deviations come from the positively informed VC, since $(1 - \alpha)V_g > (1 - \alpha)\bar{V} > (1 - \alpha)V_b$ whenever $\alpha \in (0, 1)$. Thus, the positively informed VC does indeed deviate (as does the unskilled VC), which rules out the equilibrium in which no type of VC backs the firm.

It may be worth pointing out that Cho and Kreps's (1987) intuitive criterion also rules out equilibria in which no type of VC backs the firm whenever $\overline{NPV} > 0$. This is because the intuitive criterion restricts beliefs such that bidders assign zero probability to deviations that come from VC types that would be worse off from deviating, no matter bidders' response. Since $V_b < 0$, this immediately implies that the bidders assign zero probability to deviations coming from the negatively informed VC. Thus, bidders believe that the deviating VC is at worst unskilled. For positive average NPV, bidders still provide capital and the unskilled VC deviates and backs the firm (as does the positively informed VC). For negative average NPV, however, bidders will not provide capital if they believe that the deviating VC is unskilled. Thus, I require the stronger refinement above for some parameters. \square

A.3. Proof of Corollary 1

This result follows immediately from the proof of Proposition 1. \square

A.4. Proof of Proposition 2

First, I verify that the outcome described in the proposition is an equilibrium (i.e., everyone's strategy is a best response). Second, I show that this is the unique reasonable equilibrium that is not perverse, as defined formally below.

A.4.1. Verification of the Equilibrium

In this proof, I proceed by the usual conjecture-and-verify method of finding perfect Bayesian equilibria. I conjecture an equilibrium in which (i) the positively informed VC plays $a = 1$, (ii) the negatively informed VC plays $a = 0$, and (iii) the unskilled VC plays $a = 1$ with probability μ .

Beliefs. The market observes the VC's action a and, if the IPO succeeds, it also observes the long-run realized value of the firm V_θ . Given this information,

(i) for any belief about bidders' behavior for which the unskilled VC wants to deviate, the positively informed VC wants to deviate too and (ii) for some beliefs about bidders' behavior, the positively informed VC wants to deviate but the unskilled VC does not. I cannot apply this criterion directly here, since the beliefs that make the unskilled VC want to deviate are the same as those that make the positively informed VC want to deviate, even though the positively informed VC's payoff from deviating is higher. This is because the cost of backing a firm is zero. Thus, I define a slightly stronger criterion in the text. Alternatively, I could add a small cost of VC backing and apply the D1 criterion directly to obtain the same result.

it updates its beliefs about the VC's type. The application of Bayes's rule gives the following posterior beliefs about the VC's type:

$$\mathbb{P}[s | \iota V_\theta, \alpha] = \begin{cases} 0 & \text{if } V_\theta = V_b \text{ and } \alpha = 1, \\ \frac{(1-\varphi)\gamma}{(1-\varphi)\gamma + (1-\gamma)(1-\mu)} & \text{if } \alpha = 0, \\ \frac{\gamma}{\gamma + (1-\gamma)\mu} & \text{if } V_\theta = V_g \text{ and } \alpha = 1. \end{cases}$$

Unskilled VC. If the unskilled VC backs the firm, its payoff is

$$\mathbb{E}[\Pi_{\text{RM}}^u(\alpha = 1)] = \varphi \left[\frac{\gamma}{\gamma + (1-\gamma)\mu} \right]. \quad (\text{A.4})$$

This is because, when the VC backs the firm, the IPO succeeds and the firm value is realized. The firm can be bad or good. The firm is bad with probability $1 - \varphi$, in which case the VC reveals that it is unskilled and earns nothing. With probability φ , the firm is good and the unskilled VC pools with the positively informed VC.

If the unskilled VC does not back the firm, its payoff is

$$\mathbb{E}[\Pi_{\text{RM}}^u(\alpha = 0)] = \frac{(1-\varphi)\gamma}{(1-\varphi)\gamma + (1-\gamma)(1-\mu)}. \quad (\text{A.5})$$

This is because, when it does not back the firm, the firm value is not realized and the market can only make inferences about the VC's type by observing the VC's action.

I now consider three possible cases.

- (i) *The unskilled VC always backs the firm.* $\mu^* = 1$ is an equilibrium if

$$\mathbb{E}[\Pi_{\text{RM}}^u(\alpha = 1)] \geq \mathbb{E}[\Pi_{\text{RM}}^u(\alpha = 0)], \quad (\text{A.6})$$

when $\mu^* = 1$. This reduces to

$$\varphi\gamma \geq 1, \quad (\text{A.7})$$

which is never satisfied since $\gamma \in (0, 1)$ and $\varphi \in [0, 1]$. Thus, it must be the case that $\mu^* < 1$.

- (ii) *The unskilled VC never backs the firm.* $\mu^* = 0$ is an equilibrium if

$$\mathbb{E}[\Pi_{\text{RM}}^u(\alpha = 1)] \leq \mathbb{E}[\Pi_{\text{RM}}^u(\alpha = 0)], \quad (\text{A.8})$$

when $\mu^* = 0$. This reduces to

$$\gamma \geq \frac{\varphi}{1-\varphi+\varphi^2} =: \gamma^*. \quad (\text{A.9})$$

Thus, $\mu^* = 0$ is an equilibrium if and only if $\gamma \geq \gamma^*$.

- (iii) *The unskilled VC backs the firm with probability $\mu \in (0, 1)$.* $\mu^* \in (0, 1)$ is an equilibrium if

$$\mathbb{E}[\Pi_{\text{RM}}^u(\alpha = 1)] = \mathbb{E}[\Pi_{\text{RM}}^u(\alpha = 0)] \quad (\text{A.10})$$

or

$$\varphi \left[\frac{\gamma}{\gamma + (1 - \gamma)\mu} \right] = \frac{(1 - \varphi)\gamma}{(1 - \varphi)\gamma + (1 - \gamma)(1 - \mu)}. \quad (\text{A.11})$$

This reduces to

$$\mu^* = \frac{\varphi\gamma(1 - \varphi) - \gamma + \varphi}{1 - \gamma}. \quad (\text{A.12})$$

This expression is between zero and one as long as the condition in equation (A.9) is violated. Thus, we have that there is an interior equilibrium as long as $\gamma \in [0, \gamma^*)$, which is satisfied by hypothesis.

Bound for μ^ .* Before proceeding with the proof, it is useful to establish a bound on μ^* .

LEMMA A1: *If there is an interior μ^* in equation (A.12), we have that*

$$\mu^* \leq \varphi \leq \frac{1}{2 - \varphi}. \quad (\text{A.13})$$

PROOF: The proof is by direct computation. From equation (A.12) above, we have that $\mu^* \leq \varphi$ whenever

$$\varphi\gamma(1 - \varphi) - \gamma + \varphi \leq \varphi - \gamma\varphi, \quad (\text{A.14})$$

or $\varphi \leq 1$, which is satisfied by assumption.

For the second inequality in the lemma, observe that $\varphi \leq 1/(2 - \varphi)$ whenever $(\varphi - 1)^2 \geq 0$, which is always satisfied.

Skilled VC. I must show that the positively informed VC does not have a profitable deviation from backing a good firm and that the negatively informed VC does not have a profitable deviation from not backing a bad firm. The payoff of a positively informed VC is

$$\mathbb{E}[\Pi_{\text{RM}}^s(a = 1, \theta = g)] = \frac{\gamma}{\gamma + (1 - \gamma)\mu^*} \quad (\text{A.15})$$

if it backs the firm and

$$\mathbb{E}[\Pi_{\text{RM}}^s(a = 0, \theta = g)] = \frac{(1 - \varphi)\gamma}{(1 - \varphi)\gamma + (1 - \gamma)(1 - \mu^*)} \quad (\text{A.16})$$

if it does not back the firm. The positively informed VC backs the firm if

$$\mathbb{E}[\Pi_{\text{RM}}^s(a = 1, \theta = g)] \geq \mathbb{E}[\Pi_{\text{RM}}^s(a = 0, \theta = g)]. \quad (\text{A.17})$$

This inequality reduces to $\mu^* \leq 1/(2 - \varphi)$, which is satisfied by Lemma A1 above.

The payoff of a negatively informed VC is

$$\mathbb{E}[\Pi_{\text{RM}}^s(a = 0, \theta = b)] = \frac{(1 - \varphi)\gamma}{(1 - \varphi)\gamma + (1 - \gamma)(1 - \mu^*)} \quad (\text{A.18})$$

if it does not back the firm and

$$\mathbb{E}[\Pi_{\text{RM}}^s(a = 1, \theta = b)] = 0 \tag{A.19}$$

if it does back the firm. The negatively informed VC does not back the firm if $\mathbb{E}[\Pi_{\text{RM}}^s(a = 0, \theta = b)] \geq \mathbb{E}[\Pi_{\text{RM}}^s(a = 1, \theta = b)]$. This inequality is always satisfied, since the expression in equation (A.18) is always positive.

Bidders. By Lemma 1, the IPO succeeds if the conditional expected value of the firm exceeds I . Given the equilibrium strategies, the expected value of the firm conditional on $a = 1$ is

$$\mathbb{E}[V_\theta | a = 1] = \frac{\varphi\gamma V_g + (1 - \gamma)\mu^*\bar{V}}{\varphi\gamma + (1 - \gamma)\mu^*}. \tag{A.20}$$

Thus, the IPO succeeds if

$$\frac{\varphi\gamma V_g + (1 - \gamma)\mu^*\bar{V}}{\varphi\gamma + (1 - \gamma)\mu^*} > I, \tag{A.21}$$

or

$$\varphi\gamma \text{NPV}_g + (1 - \gamma)\mu^*\overline{\text{NPV}} > 0. \tag{A.22}$$

There are now two cases to be considered: (i) $\gamma \geq \gamma^*$, so $\mu^* = 0$, and (ii) $\gamma < \gamma^*$, so μ^* is as defined in equation (A.12).

In case (i), inequality (A.22) is always satisfied. In fact, the inequality can be rewritten as

$$\varphi\gamma \text{NPV}_g > 0, \tag{A.23}$$

which is always satisfied.²⁵

In case (ii), inequality (A.22) is satisfied whenever

$$\varphi\gamma \text{NPV}_g + (\varphi\gamma(1 - \varphi) - \gamma + \varphi)\overline{\text{NPV}} > 0. \tag{A.24}$$

This is the condition given in the statement of the proposition. □

Equilibrium Selection in the Reputation-Motivation Equilibrium

In Proposition 2, I characterize the equilibria in which backing a good firm sends a positive signal about the VC’s skill. However, there may be other equilibria. In this subsection, I show that they are not robust to a refinement, which I introduce now.

Here, I extend the model to include a small number of behavioral types in order to remove equilibria that are supported by “unreasonable” beliefs off the equilibrium path. Specifically, suppose that, with probability η , the skilled VC “follows its signal,” that is, it backs if the firm is good and does not back if the firm is bad. I also assume that if the VC backs the firm, the true type of the

²⁵ Note that $\gamma > 0$ and $\varphi > 0$ by Parameter Restriction 1 and $V_b < 0$.

firm is revealed with probability δ .²⁶ I focus on the limit in which η and δ go to zero ($\eta = \delta = 0$ in the baseline model). By introducing “noise” in this way, I ensure that there is not an action $a \in \{0, 1\}$ that is always off the equilibrium path. Thus, I no longer have to deal with off-equilibrium-path beliefs.

I now define a *perverse* equilibrium.

DEFINITION 2: *An equilibrium is perverse if beliefs are such that backing a good firm is viewed as a negative signal about VC skill and backing a bad firm is viewed as a positive signal about VC skill, that is,*

$$\mathbb{P}[s|a = 1, V_b] \geq \mathbb{P}[s|a = 1, V_g]. \quad (\text{A.25})$$

I restrict attention to nonperverse equilibria, since in perverse equilibria, the unskilled VC would make higher profits than the skilled VC and hence investors would prefer to invest with the unskilled VC rather than with the skilled VC.

The next result says that the equilibria characterized in Proposition 2 above constitute all reasonable, nonperverse equilibria.

PROPOSITION 10: *For $\eta \rightarrow 0^+$ and $\delta \rightarrow 0^+$, the equilibrium in Proposition 2 is the unique equilibrium that is not perverse.*

This result says that as long as investors believe that a VC is more likely to be skilled if it backs a good firm than if it backs a bad firm, then the positively informed VC backs the firm and the negatively informed VC does not.

PROOF: First, observe that there is no equilibrium in which all (strategic) types of VC play $a = 0$ or $a = 1$. This is because there is always a proportion of skilled behavioral types playing the other action. As a result, in any such pooling equilibrium, the VC has an incentive to deviate to the other action and pool with these behavioral types, since it will be believed to be skilled.

Now I must show that there can be no nonperverse equilibrium in which the skilled negatively informed VC backs the firm and the skilled positively informed VC does not back the firm.²⁷ I prove that this cannot be the case by contradiction.

Suppose that a nonperverse equilibrium exists in which the skilled negatively informed VC backs the firm and the skilled positively informed VC does not back the firm. Then, the following two conditions must be satisfied:

- (1) The skilled negatively informed VC (weakly) prefers to play $a = 1$.
- (2) The skilled positively informed VC (weakly) prefers to play $a = 0$.

²⁶ Including assets in place as in Section IV.A provides a microfoundation for this assumption.

²⁷ This includes mixed strategies. Formally, there can be no equilibrium in which both (i) the skilled negatively informed VC plays $a = 1$ with positive probability and (ii) the skilled positively informed VC plays $a = 0$ with positive probability.

Substituting for the reputation-motivated VC's payoff, we can express these conditions as follows:

$$\delta \mathbb{P}[s | a = 1, V_b] + (1 - \delta) \mathbb{P}[s | a = 1, \iota V_b] \geq \mathbb{P}[s | a = 0] \tag{A.26}$$

and

$$\mathbb{P}[s | a = 0] \geq \delta \mathbb{P}[s | a = 1, V_g] + (1 - \delta) \mathbb{P}[s | a = 1, \iota V_g]. \tag{A.27}$$

Combining these inequalities implies that

$$\begin{aligned} \delta \mathbb{P}[s | a = 1, V_b] + (1 - \delta) \mathbb{P}[s | a = 1, \iota V_b] &\geq \delta \mathbb{P}[s | a = 1, V_g] \\ &+ (1 - \delta) \mathbb{P}[s | a = 1, \iota V_g]. \end{aligned} \tag{A.28}$$

There are two cases to consider, $\iota = 0$ and $\iota = 1$. If $\iota = 0$, it follows that $\mathbb{P}[s | a = 1, \iota V_g] = \mathbb{P}[s | a = 1, \iota V_b]$ so we have that

$$\mathbb{P}[s | a = 1, V_b] \geq \mathbb{P}[s | a = 1, V_g], \tag{A.29}$$

which implies that the equilibrium is perverse. Thus, it must be the case that $\iota = 1$. But in this case, the inequality above reads

$$\begin{aligned} \delta \mathbb{P}[s | a = 1, V_b] + (1 - \delta) \mathbb{P}[s | a = 1, V_b] &\geq \delta \mathbb{P}[s | a = 1, V_g] \\ &+ (1 - \delta) \mathbb{P}[s | a = 1, V_g] \end{aligned} \tag{A.30}$$

or

$$\mathbb{P}[s | a = 1, V_b] \geq \mathbb{P}[s | a = 1, V_g], \tag{A.31}$$

which, again, implies that the equilibrium is perverse. This contradicts the hypothesis. Thus, in all reasonable, nonperverse equilibria, the skilled positively informed VC plays $a = 1$ and the skilled negatively informed VC plays $a = 0$. \square

A.5. Proof of Lemma 2

I first verify that, in equilibrium, the positively informed VC backs the firm, the negatively informed VC does not back the firm, and the unskilled VC randomizes, backing the firm with probability $\hat{\mu}$. The proof is analogous to the proof of Proposition 2 (hence, I keep the derivation brief; see the proof of Proposition 2 for more detailed explanations of the steps). Next, I compare the behavior of the unskilled VC in this equilibrium with that in Proposition 2.

Beliefs. The market observes the VC's action a and the long-run realized value of the firm V_θ . Given this information, it updates its beliefs about the VC's type according to

$$\mathbb{P}[s | \iota V_\theta, a] = \begin{cases} \frac{\gamma}{\gamma + (1-\gamma)(1-\mu)} & \text{if } V_\theta = V_b \quad \text{and} \quad a = 0, \\ 0 & \text{if } V_\theta = V_b \quad \text{and} \quad a = 1 \quad \text{or} \quad V_\theta = V_g \quad \text{and} \quad a = 0, \\ \frac{\gamma}{\gamma + (1-\gamma)\mu} & \text{if } V_\theta = V_g \quad \text{and} \quad a = 1. \end{cases}$$

Unskilled VC. If the unskilled VC backs the firm, its payoff is

$$\mathbb{E}[\Pi_{RM}^u(a = 1)] = \varphi \left[\frac{\gamma}{\gamma + (1 - \gamma)\mu} \right]. \tag{A.32}$$

If the unskilled VC does not back the firm, its payoff is

$$\mathbb{E}[\Pi_{RM}^u(a = 0)] = (1 - \varphi) \left[\frac{\gamma}{\gamma + (1 - \gamma)(1 - \mu)} \right]. \tag{A.33}$$

I now consider three possible cases.

(i) *The unskilled VC always backs the firm.* $\hat{\mu} = 1$ is an equilibrium if

$$\mathbb{E}[\Pi_{RM}^u(a = 1)] \geq \mathbb{E}[\Pi_{RM}^u(a = 0)], \tag{A.34}$$

when $\hat{\mu} = 1$. This reduces to

$$\varphi\gamma \geq 1 - \varphi. \tag{A.35}$$

Thus, $\hat{\mu} = 1$ is an equilibrium if and only if $\gamma \in [\frac{1-\varphi}{\varphi}, 1]$, where the interval is nonempty if and only if $\varphi \in [\frac{1}{2}, 1]$.

(ii) *The unskilled VC never backs the firm.* $\hat{\mu} = 0$ is an equilibrium if

$$\mathbb{E}[\Pi_{RM}^u(a = 1)] \leq \mathbb{E}[\Pi_{RM}^u(a = 0)] \tag{A.36}$$

when $\hat{\mu} = 0$. This reduces to

$$\varphi \leq (1 - \varphi)\gamma. \tag{A.37}$$

Thus, $\hat{\mu} = 0$ is an equilibrium if and only if $\gamma \in [\frac{\varphi}{1-\varphi}, 1]$, where the interval is nonempty if and only if $\varphi \in [0, \frac{1}{2}]$.

(iii) *The unskilled VC backs the firm with probability $\mu \in (0, 1)$.* $\hat{\mu} \in (0, 1)$ is an equilibrium if

$$\mathbb{E}[\Pi_{RM}^u(a = 1)] = \mathbb{E}[\Pi_{RM}^u(a = 0)] \tag{A.38}$$

or

$$\varphi \left[\frac{\gamma}{\gamma + (1 - \gamma)\mu} \right] = (1 - \varphi) \left[\frac{\gamma}{\gamma + (1 - \gamma)(1 - \mu)} \right]. \tag{A.39}$$

This reduces to

$$\hat{\mu} = \frac{\varphi - \gamma(1 - \varphi)}{1 - \gamma}. \tag{A.40}$$

Skilled VC. The payoff of a positively informed VC is

$$\mathbb{E}[\Pi_{RM}^s(a = 1, \theta = g)] = \frac{\gamma}{\gamma + (1 - \gamma)\hat{\mu}} \tag{A.41}$$

if it backs the firm and

$$\mathbb{E}[\Pi_{RM}^s(a = 0, \theta = g)] = 0 \tag{A.42}$$

if it does not back the firm. Thus, the positively informed VC always back the firm.

The payoff of a negatively informed VC is

$$\mathbb{E}[\Pi_{RM}^s(a = 0, \theta = b)] = \frac{\gamma}{\gamma + (1 - \gamma)(1 - \hat{\mu})} \tag{A.43}$$

if it does not back the firm and

$$\mathbb{E}[\Pi_{RM}^s(a = 1, \theta = b)] = 0 \tag{A.44}$$

if it does back the firm. Thus, the negatively informed VC never backs the firm.

Comparison between $\hat{\mu}$ and μ^ .* In the benchmark here, the unskilled VC backs the firm with probability $\hat{\mu}$, where

$$\hat{\mu} = \begin{cases} 0 & \text{if } \varphi \in [0, \frac{1}{2}] \text{ and } \gamma \in [\frac{\varphi}{1-\varphi}, 1], \\ 1 & \text{if } \varphi \in [\frac{1}{2}, 1] \text{ and } \gamma \in [\frac{1-\varphi}{\varphi}, 1], \\ \frac{\varphi - \gamma(1-\varphi)}{1-\gamma} & \text{otherwise.} \end{cases} \tag{A.45}$$

In Proposition 2, the unskilled backs the firm with probability μ^* , where

$$\mu^* = \begin{cases} 0 & \text{if } \gamma \in [\frac{\varphi}{1-\varphi+\varphi^2}, 1], \\ \frac{\varphi\gamma(1-\varphi) - \gamma + \varphi}{1-\gamma} & \text{otherwise.} \end{cases} \tag{A.46}$$

Consider three cases: (i) $\gamma \in [\frac{\varphi}{1-\varphi+\varphi^2}, 1]$, (ii) $\gamma \in [0, \frac{\varphi}{1-\varphi+\varphi^2}]$ and $\varphi \leq 1/2$, and (iii) $\gamma \in [0, \frac{\varphi}{1-\varphi+\varphi^2}]$ and $\varphi > 1/2$. In (i), $\mu^* = 0$, so $\mu^* \leq \hat{\mu}$. In (ii), $\gamma < \frac{\varphi}{1-\varphi+\varphi^2}$ implies that $\gamma < \frac{\varphi}{1-\varphi}$. In this case,

$$\hat{\mu} = \frac{\varphi - \gamma(1 - \varphi)}{1 - \gamma} > \max \left\{ 0, \frac{\varphi\gamma(1 - \varphi) - \gamma + \varphi}{1 - \gamma} \right\} = \mu^*.$$

In (iii),

$$\hat{\mu} = \min \left\{ 1, \frac{\varphi - \gamma(1 - \varphi)}{1 - \gamma} \right\} \geq \mu^*$$

by the argument in (ii). □

A.6. Proof of Lemma 3

The result follows from differentiating the expression for μ^* in equation (10). The result is immediate if $\mu^* = 0$, since all derivatives are zero. If $\mu^* > 0$, we have

$$\frac{\partial \mu^*}{\partial \varphi} = \frac{1 + \gamma(1 - 2\varphi)}{1 - \gamma} > 0 \tag{A.47}$$

and

$$\frac{\partial \mu^*}{\partial \gamma} = -\frac{(1 - \varphi)^2}{(1 - \gamma)^2} < 0. \tag{A.48}$$

□

A.7. Proof of Corollary 2

The proof follows immediately from Proposition 2. When inequality (A.22) is not satisfied, there is a market breakdown with a reputation-motivated VC. That is, there is a market breakdown if

$$\varphi\gamma\text{NPV}_g + (1 - \gamma)\mu^*\overline{\text{NPV}} \leq 0, \tag{A.49}$$

or, substituting for μ^* from equation (A.12), if $\gamma < \varphi/(1 - \varphi + \varphi^2)$ and

$$\varphi\gamma\text{NPV}_g + (\varphi\gamma(1 - \varphi) - \gamma + \varphi)\overline{\text{NPV}} \leq 0, \tag{A.50}$$

as stated in the proposition. □

A.8. Proof of Lemma 4

The result follows immediately from comparing the profit-motivation equilibrium in Proposition 1 with the reputation-motivation equilibrium in Proposition 2. In particular, it follows from $\mu^* < 1$. □

A.9. Proof of Lemma 5

Comparing the value of the firm when a profit-motivated VC backs it in equality (A.2) with the value of the firm when a reputation-motivated VC backs it in equality (A.20), we find that

$$\mathbb{E}[V_\theta | \alpha = 1]_{\text{IRM}} - \mathbb{E}[V_\theta | \alpha = 1]_{\text{PM}} = 0 \tag{A.51}$$

whenever $\mu^* = 1$. Since

$$\frac{\partial \mathbb{E}[V_\theta | \alpha = 1]_{\text{IRM}}}{\partial \mu} = -\frac{\varphi(1 - \varphi)\gamma(1 - \gamma)(V_g - V_b)}{(\varphi\gamma + \mu(1 - \gamma))^2} < 0 \tag{A.52}$$

and $\mathbb{E}[V_\theta | \alpha = 1]_{\text{PM}}$ does not depend on μ , $\mathbb{E}[V_\theta | \alpha = 1]_{\text{IRM}} - \mathbb{E}[V_\theta | \alpha = 1]_{\text{PM}}$ is decreasing in μ . In other words, inequality (12) is hardest to satisfy when $\mu = 1$. Thus, since it is satisfied when $\mu = 1$, it is always satisfied. □

A.10. Proof of Proposition 3

If VCs are profit-motivated, there is a market breakdown whenever inequality (8) is satisfied, or if

$$\tau_{PM} := \varphi\gamma NPV_g + (1 - \gamma)\overline{NPV} \leq 0; \tag{A.53}$$

if they are reputation-motivated, there is a market breakdown whenever inequality (A.49) is satisfied, or if

$$\tau_{RM} := \varphi\gamma NPV_g + (1 - \gamma)\mu^*\overline{NPV} \leq 0. \tag{A.54}$$

Note that there are no breakdowns if $\overline{NPV} \geq 0$, so I focus on the case in which $\overline{NPV} < 0$.

To prove the proposition, I must show that $\tau_{RM} \leq 0$ implies $\tau_{PM} \leq 0$. This is the case since

$$\begin{aligned} 0 &\geq \tau_{RM} \\ &= \varphi\gamma NPV_g + (1 - \gamma)\mu^*\overline{NPV} \\ \varphi &> \gamma NPV_g + (1 - \gamma)\mu^*\overline{NPV} + \gamma\mu^*\overline{NPV} \\ &= \tau_{PM}. \end{aligned}$$

□

A.11. Proof of Proposition 4

Let us consider the case in which there is an IPO both when a VC is profit-motivated and when it is reputation-motivated (Propositions 1 and 2). In this case, the expected productive efficiency (as defined in Definition 1) when the VC is profit-motivated is

$$\mathbb{E}[W_{PM}] = \varphi\gamma NPV_g + (1 - \gamma)\overline{NPV}, \tag{A.55}$$

and the expected productive efficiency when it is reputation-motivated is

$$\mathbb{E}[W_{RM}] = \varphi\gamma NPV_g + (1 - \gamma)\mu^*\overline{NPV}. \tag{A.56}$$

Productive efficiency is strictly higher when the VC is reputation-motivated if $\mathbb{E}[W_{RM}] > \mathbb{E}[W_{PM}]$, or if

$$\overline{NPV} < 0. \tag{A.57}$$

□

A.12. Proof of Corollary 3

The proof is by direct computation. Define

$$\Delta W := \mathbb{E}[W_{RM}] - \mathbb{E}[W_{PM}]. \tag{A.58}$$

Substituting from equations (A.55) and (A.56), we have

$$\begin{aligned} \Delta W &= (\varphi\gamma\text{NPV}_g + (1 - \gamma)\mu^*\overline{\text{NPV}}) - (\varphi\gamma\text{NPV}_g + (1 - \gamma)\overline{\text{NPV}}) \\ &= -(1 - \gamma)(1 - \mu^*)\overline{\text{NPV}}. \end{aligned} \tag{A.59}$$

Substituting for μ^* from equation (10) into the expression for ΔW in equation (A.59), we have

$$\Delta W = \begin{cases} -(1 - \gamma)\overline{\text{NPV}} & \text{if } \mu^* = 0, \\ -(1 - \varphi)(1 - \varphi\gamma)\overline{\text{NPV}} & \text{otherwise.} \end{cases} \tag{A.60}$$

Notice that $\overline{\text{NPV}}$ does not depend on γ , so in both cases $\frac{\partial \Delta W}{\partial \gamma} < 0$ if and only if $\overline{\text{NPV}} < 0$. The result follows from Proposition 4, which says that $\Delta W > 0$ if and only if $\overline{\text{NPV}} < 0$. \square

A.13. Proof of Corollary 4

The result follows from equation (A.60) above. If $\mu^* = 0$, the result is immediate since $\overline{\text{NPV}} = \varphi V_g + (1 - \varphi)V_b$ is increasing in φ . If $\mu^* \neq 0$, the result follows from direct computation:

$$\frac{\partial \Delta W}{\partial \varphi} = (1 - \gamma\varphi)\overline{\text{NPV}} + \gamma(1 - \varphi)\overline{\text{NPV}} - (1 - \varphi)(1 - \gamma\varphi)(V_g - V_b). \tag{A.61}$$

This is negative since, for $\overline{\text{NPV}} < 0$, each of the terms above is negative. \square

A.14. Proof of Lemma 6

The proof of this lemma is analogous to that of Proposition 2, which characterizes the reputation-motivation equilibrium. The only substantive difference is that with probably q , the VC’s type is revealed even if the firm does not get VC backing.

Beliefs. The market updates its beliefs given what is publicly observable. If the firm receives backing from the VC ($\alpha = 1$), then the market observes V_θ . If the firm does not receive backing from the VC ($\alpha = 0$), then the market observes the value of the assets in place v_θ if the firm continues ($\chi = 1$). If the firm does not continue ($\chi = 0$), the market observes nothing about the quality of the firm. Applying Bayes’s rule gives the following expression for the market’s beliefs:

$$\mathbb{P}[s \mid \iota V_\theta, \alpha, (1 - \iota)\chi v_\theta] = \begin{cases} 0 & \text{if } V_\theta = V_b \text{ and } \alpha = 1, \\ 0 & \text{if } \chi = 1, v_\theta = v_g, \text{ and } \alpha = 0, \\ \frac{(1-\varphi)\gamma}{(1-\varphi)\gamma + (1-\gamma)(1-\mu)} & \text{if } \chi = 0 \text{ and } \alpha = 0, \\ \frac{\gamma}{\gamma + (1-\gamma)(1-\mu)} & \text{if } \chi = 1, v_\theta = v_b, \text{ and } \alpha = 0, \\ \frac{\gamma}{\gamma + (1-\gamma)\mu} & \text{if } V_\theta = V_g \text{ and } \alpha = 1. \end{cases}$$

Unskilled VC. If the unskilled VC backs the firm, its payoff is

$$\mathbb{E}[\Pi_{\text{RM}}^u(a = 1)] = \frac{\varphi\gamma}{\gamma + (1 - \gamma)\mu}. \tag{A.62}$$

If the unskilled VC does not back the firm, its payoff is

$$\mathbb{E}[\Pi_{\text{RM}}^u(a = 0)] = \frac{(1 - q)(1 - \varphi)\gamma}{(1 - \varphi)\gamma + (1 - \gamma)(1 - \mu)} + \frac{q(1 - \varphi)\gamma}{\gamma + (1 - \gamma)(1 - \mu)}. \tag{A.63}$$

I now consider three possible cases.

(i) *The unskilled VC always backs the firm.* $\mu^q = 1$ is an equilibrium if

$$\mathbb{E}[\Pi_{\text{RM}}^u(a = 1)] \geq \mathbb{E}[\Pi_{\text{RM}}^u(a = 0)], \tag{A.64}$$

when $\mu = 1$. This reduces to

$$\gamma\varphi \geq 1 - q\varphi, \tag{A.65}$$

or

$$\gamma \geq \frac{1 - q\varphi}{\varphi} =: \gamma_1^q. \tag{A.66}$$

So, $\mu^q = 1$ is an equilibrium if $\gamma \in [\gamma_1^q, 1]$. This interval is nonempty if and only if $\gamma_1^q \leq 1$ or if both $\varphi \in [\frac{1}{2}, 1]$ and $q \in [\frac{1 - \varphi}{\varphi}, 1]$.

(ii) *The unskilled VC never backs the firm.* $\mu^q = 0$ is an equilibrium if

$$\mathbb{E}[\Pi_{\text{RM}}^u(a = 1)] \leq \mathbb{E}[\Pi_{\text{RM}}^u(a = 0)] \tag{A.67}$$

when $\mu = 0$. This reduces to

$$\frac{\gamma(1 - \varphi + \varphi^2) - \varphi\gamma^2q(1 - \varphi) - \varphi}{1 - \varphi\gamma} \geq 0. \tag{A.68}$$

Solving the quadratic equation above for γ , this implies that $\mu^q = 0$ if and only if

$$\gamma \geq \frac{1 - \varphi + \varphi^2 + \sqrt{(1 - \varphi + \varphi^2)^2 + 4\varphi^2q(1 - \varphi)}}{2q\varphi(1 - \varphi)} =: \gamma_0^q. \tag{A.69}$$

(Note that we can restrict attention to the larger root of the quadratic equation above, since the smaller root is always negative.) Thus, $\mu^q = 0$ is an equilibrium if $\gamma \in [\gamma_0^q, 1]$. This interval is nonempty if and only if $\gamma_0^q \leq 1$ or if either $\varphi \in [0, \frac{1}{2}]$ or both $\varphi \in [\frac{1}{2}, 1]$ and $q \in [0, \frac{1 - \varphi}{\varphi}]$.

(iii) *The unskilled VC backs the firm with probability $\mu^q \in (0, 1)$.* The VC must be indifferent between backing the firm and not backing the firm, that is,

$$\mathbb{E}[\Pi_{\text{RM}}^u(a = 1)] = \mathbb{E}[\Pi_{\text{RM}}^u(a = 0)], \tag{A.70}$$

or

$$\frac{\varphi\gamma}{\gamma + (1 - \gamma)\mu} = \frac{(1 - q)(1 - \varphi)\gamma}{(1 - \varphi)\gamma + (1 - \gamma)(1 - \mu)} + \frac{(1 - \varphi)q\gamma}{\gamma + (1 - \gamma)(1 - \mu)}. \tag{A.71}$$

This is a quadratic equation in μ . Define m^q as its solution. So, there is an interior equilibrium whenever $m^q \in (0, 1)$.

To summarize the unskilled VC's equilibrium mixing probability μ^q is

$$\mu^q = \begin{cases} 0 & \text{if } \gamma \in [\gamma_0^q, 1], \\ 1 & \text{if } \gamma \in [\gamma_1^q, 1], \\ m^q & \text{otherwise.} \end{cases} \tag{A.72}$$

Note that it is never the case that both $\gamma_0^q < 1$ and $\gamma_1^q < 1$, so μ^q above is generically unique.

Positively informed VC. The payoff of a positively informed VC is

$$\mathbb{E}[\Pi_{\text{RM}}^s(a = 1, \theta = g)] = \frac{\gamma}{\gamma + (1 - \gamma)\mu^q} \tag{A.73}$$

if it backs the firm and

$$\mathbb{E}[\Pi_{\text{RM}}^s(a = 0, \theta = g)] = \frac{(1 - q)(1 - \varphi)\gamma}{(1 - \varphi)\gamma + (1 - \gamma)(1 - \mu^q)} \tag{A.74}$$

if it does not back the firm.

The positively informed VC backs the firm if

$$\mathbb{E}[\Pi_{\text{RM}}^s(a = 1, \theta = g)] \geq \mathbb{E}[\Pi_{\text{RM}}^s(a = 0, \theta = g)].$$

This is always satisfied. To see this, consider three cases, (i) $\mu^q \in (0, 1)$, (ii) $\mu^q = 1$, and (iii) $\mu^q = 0$.

- (i) $\mu^q \in (0, 1)$. In this case, the unskilled VC is indifferent between backing the firm and not backing the firm. Relative to the unskilled VC, the positively informed VC has a higher expected payoff from backing the firm and a lower expected payoff from not backing the firm, so it always prefers to back the firm:

$$\begin{aligned} \mathbb{E}[\Pi_{\text{RM}}^s(a = 1, \theta = g)] &\geq \mathbb{E}[\Pi_{\text{RM}}^u(a = 1)] = \mathbb{E}[\Pi_{\text{RM}}^u(a = 0)] \\ &\geq \mathbb{E}[\Pi_{\text{RM}}^s(a = 0, \theta = g)] \end{aligned} \tag{A.75}$$

by comparing equation (A.73) with equation (A.62), and equation (A.74) with equation (A.63).

- (ii) $\mu^q = 1$. In this case, the unskilled VC always prefers to back the firm to not backing the firm. By an analogous argument to case (i), the skilled VC also prefers to back the firm:

$$\mathbb{E}[\Pi_{\text{RM}}^s(a = 1, \theta = g)] \geq \mathbb{E}[\Pi_{\text{RM}}^u(a = 1)] \geq \mathbb{E}[\Pi_{\text{RM}}^u(a = 0)]$$

$$\geq \mathbb{E}[\Pi_{\text{RM}}^s(a = 0, \theta = g)]. \quad (\text{A.76})$$

(iii) $\mu^q = 0$. In this case, the unskilled VC never backs the firm. Thus, the skilled positively informed VC is never pooled with the unskilled VC if it backs the firm. In equilibrium, therefore, the positively informed VC gets payoff equal to one, given it knows the firm is good.

Negatively informed VC. The payoff of a negatively informed VC is

$$\mathbb{E}[\Pi_{\text{RM}}^s(a = 0, \theta = b)] = \frac{(1 - q)(1 - \varphi)\gamma}{(1 - \varphi)\gamma + (1 - \gamma)(1 - \mu^q)} + \frac{q\gamma}{\gamma + (1 - \gamma)(1 - \mu^q)} \quad (\text{A.77})$$

if it does not back the firm and

$$\mathbb{E}[\Pi_{\text{RM}}^s(a = 1, \theta = b)] = 0 \quad (\text{A.78})$$

if it does back the firm. Thus, it does not back the firm.

Bidders. By Lemma 1, the IPO succeeds if the conditional expected value of the firm exceeds I . Given the equilibrium strategies, the expected value of the firm conditional on VC backing is

$$\mathbb{E}[V_\theta | a = 1] = \frac{\varphi\gamma V_g + (1 - \gamma)\mu^q \bar{V}}{\varphi\gamma + (1 - \gamma)\mu^q}. \quad (\text{A.79})$$

Thus, the IPO succeeds if

$$\frac{\varphi\gamma V_g + (1 - \gamma)\mu^q \bar{V}}{\varphi\gamma + (1 - \gamma)\mu^q} > I. \quad (\text{A.80})$$

This is the condition in the proposition. \square

A.15. Proof of Lemma 7

To see that $\mu^q = \mu^*$ when $q = 0$ and $\mu^q = \hat{\mu}$ when $q = 1$, observe that equation (A.71), which defines μ^q , coincides with equation (A.11), which defines μ^* when $q = 0$, and with equation (A.39), which defines $\hat{\mu}$ when $q = 1$.

From equation (A.71), μ^q is the solution of

$$\frac{\varphi\gamma}{\gamma + (1 - \gamma)\mu} - \frac{(1 - q)(1 - \varphi)\gamma}{(1 - \varphi)\gamma + (1 - \gamma)(1 - \mu)} - \frac{q(1 - \varphi)\gamma}{\gamma + (1 - \gamma)(1 - \mu)} = 0. \quad (\text{A.81})$$

Implicitly differentiating with respect to q gives

$$\frac{\partial \mu^q}{\partial q} = \frac{\frac{\gamma(1 - \varphi)}{(1 - \varphi)\gamma + (1 - \gamma)(1 - \mu)} - \frac{\gamma(1 - \varphi)}{\gamma + (1 - \gamma)(1 - \mu)}}{\frac{q(1 - \gamma)\gamma(1 - \varphi)}{(\gamma + (1 - \gamma)(1 - \mu))^2} + \frac{(1 - \gamma)\gamma\varphi}{(\gamma + (1 - \gamma)\mu)^2} + \frac{(1 - q)(1 - \gamma)\gamma(1 - \varphi)}{((1 - \varphi)\gamma + (1 - \gamma)(1 - \mu))^2}} \geq 0, \quad (\text{A.82})$$

since both the numerator and denominator are positive. This derivative always exists, so μ^q is continuous in q . \square

A.16. Proof of Proposition 5

The result follows directly from differentiation. First, compute the difference in IPO values as

$$\mathbb{E}[V_\theta | \alpha = 1]_{\text{IRM}} - \mathbb{E}[V_\theta | \alpha = 1]_{\text{PM}} = \frac{(V_g - \overline{\text{NPV}})(1 - \gamma)\gamma\varphi(1 - \mu^q)}{(\varphi\gamma + 1 - \gamma)(\varphi\gamma + (1 - \gamma)\mu^q)}, \quad (\text{A.83})$$

where $\mathbb{E}[V_\theta | \alpha = 1]_{\text{IRM}}$ is defined in equation (A.79) and $\mathbb{E}[V_\theta | \alpha = 1]_{\text{PM}}$ is defined in equation (A.2). Note that this difference is decreasing in q :

$$\frac{\partial}{\partial q} \left(\mathbb{E}[V_\theta | \alpha = 1]_{\text{IRM}} - \mathbb{E}[V_\theta | \alpha = 1]_{\text{PM}} \right) = - \frac{(V_g - \overline{\text{NPV}})(1 - \gamma)\gamma\varphi \frac{\partial \mu^q}{\partial q}}{(\varphi\gamma + (1 - \gamma)\mu^q)^2}, \quad (\text{A.84})$$

since $\partial \mu^q / \partial q \geq 0$ by Lemma 7 and $V_g - \overline{\text{NPV}} > 0$.

Second, compute the difference in productive efficiency as

$$|\mathbb{E}[W_{\text{RM}}] - \mathbb{E}[W_{\text{PM}}]| = |(1 - \gamma)(1 - \mu^q)\overline{\text{NPV}}|. \quad (\text{A.85})$$

Note that this difference is decreasing in q :

$$\frac{\partial |\mathbb{E}[W_{\text{RM}}] - \mathbb{E}[W_{\text{PM}}]|}{\partial q} = - \frac{\partial \mu^q}{\partial q} |\overline{\text{NPV}}|, \quad (\text{A.86})$$

since $\partial \mu^q / \partial q \geq 0$ by Lemma 7.

A.17. Proof of Lemma 8

The IPO is successful whenever the condition of Lemma 1 holds, or, given that all types of VC back the firm (so $\alpha = 1$ is uninformative), if

$$\mathbb{E}[V_\theta] - I \equiv \overline{\text{NPV}} > 0, \quad (\text{A.87})$$

which holds by the hypothesis in the lemma.

Notice that each type of VC gets $\overline{\text{NPV}}$ if it backs the firm. Thus, again since $\overline{\text{NPV}} > 0$, each type does indeed back the firm. \square

A.18. Proof of Proposition 6

IPO Value. With exit at the IPO, all types of VC back the firm, so the expected firm value at IPO is just the unconditional expected firm value,

$$\mathbb{E}[V_\theta | \alpha = 1]_{\text{PM, exit}} = \varphi V_g + (1 - \varphi)V_b. \quad (\text{A.88})$$

This is less than the expression for $\mathbb{E}[V_\theta | \alpha = 1]_{\text{PM, retention}}$ in equation (A.2).

Market Breakdowns. Market breakdowns occur whenever the expected firm value conditional on VC backing is below I . The result above on the IPO value implies that this is more likely in the version with exit at the IPO than in the baseline model.

Productive Efficiency. First, observe that we can focus on the case in which the IPO is successful in the reputation-motivation equilibrium. This is because if the IPO is unsuccessful in the reputation-motivation equilibrium, it is also unsuccessful in the profit-motivation equilibrium (see the market breakdowns part of this proposition, proved above); thus, productive efficiency is zero in both cases.

Notice that if the IPO is successful, productive efficiency in the profit-motivation equilibrium with exit at the IPO is at most $\overline{\text{NPV}}$ and, as before, the productive efficiency in the reputation-motivation equilibrium is given by equation (A.56),

$$\mathbb{E}[W_{\text{RM}}] = \varphi\gamma\text{NPV}_g + (1 - \gamma)\mu^*\overline{\text{NPV}}. \tag{A.89}$$

Thus, reputation motivation increases productive efficiency whenever $\overline{\text{NPV}} < \mathbb{E}[W_{\text{RM}}]$, or

$$\overline{\text{NPV}} < \frac{\varphi\gamma\text{NPV}_g}{1 - (1 - \gamma)\mu^*}, \tag{A.90}$$

which is the condition in the proposition. □

A.19. Proof of Lemma 9

First, I present two lemmas describing the profit-motivation equilibrium (Lemma A2) and the reputation-motivation equilibrium (Lemma A3). I then prove Lemma 9.

LEMMA A2: *Suppose the VC is profit motivated. If*

$$(1 - \delta)\varphi\text{NPV}_g + (1 - \varphi)(1 - \gamma)\text{NPV}_b > 0, \tag{A.91}$$

then there is an equilibrium in which the positively informed VC and the unskilled VC back the firm and the negatively informed VC does not. If condition (A.91) is violated, then the VC does not back the firm.

PROOF: The proof of this lemma is identical to the proof of Proposition 1 with the exception of the behavior of the uninformed bidders. Hence, I omit the majority of the proof.

Bidders. Given the behavior of the VC described in Lemma A2, we can solve for the price from equation (22) and find that

$$p_{\text{PM}} = \frac{(1 - \delta)\varphi V_g + (1 - \varphi)(1 - \gamma)V_b}{(1 - \delta)\varphi + (1 - \varphi)(1 - \gamma)}. \tag{A.92}$$

The IPO succeeds if and only if the firm can sell enough shares to successfully invest I in the project. That is, the total money raised p_{PM} must be at least I

or

$$\frac{(1-\delta)\varphi V_g + (1-\varphi)(1-\gamma)V_b}{(1-\delta)\varphi + (1-\varphi)(1-\gamma)} > I, \quad (\text{A.93})$$

which is the condition in the lemma above.

LEMMA A3: *Suppose the VC is reputation-motivated. If $\gamma \geq \varphi/(1-\varphi+\varphi^2)$ or*

$$(1-\delta)\varphi^2(1+(1-\varphi)\gamma)\text{NPV}_g + (1-\varphi)(\varphi\gamma(1-\varphi) - \gamma + \varphi)\text{NPV}_b > 0, \quad (\text{A.94})$$

there is an equilibrium in which the positively informed VC backs the firm, the negatively informed VC does not back the firm, and the unskilled VC backs the firm with probability μ^ as defined in equation (A.12). If $\gamma < \varphi/(1-\varphi+\varphi^2)$ and condition (A.94) is violated, then the VC does not back the firm.*

PROOF: The proof of this lemma is identical to the proof of Proposition 2 with the exception of the behavior of the uninformed bidders. Hence, I omit the majority of the proof.

Bidders. Given the behavior of the VC described in Lemma A2, we can solve for the price from equation (22) and find that

$$p_{\text{RM}} = \frac{(1-\delta)\varphi(\gamma + (1-\gamma)\mu^*)V_g + (1-\varphi)(1-\gamma)\mu^*V_b}{(1-\delta)\varphi(\gamma + (1-\gamma)\mu^*) + (1-\varphi)(1-\gamma)\mu^*}. \quad (\text{A.95})$$

The IPO succeeds if and only if the firm can sell enough shares to successfully invest I in the project. That is, the total money raised p_{RM} must be at least I or

$$\frac{(1-\delta)\varphi(\gamma + (1-\gamma)\mu^*)V_g + (1-\varphi)(1-\gamma)\mu^*V_b}{(1-\delta)\varphi\gamma + (1-\gamma)\mu^*} > I. \quad (\text{A.96})$$

Substituting for μ^* from equation (A.12) yields the condition in the lemma above.

From directly comparing p_{RM} and p_{PM} (equations (A.95) and (A.92)), we find

$$\begin{aligned} p_{\text{RM}} - p_{\text{PM}} &= \frac{(1-\delta)\gamma(1-\gamma)(1-\mu)\varphi(1-\varphi)(V_g - V_b)}{((1-\delta)\varphi(\gamma + (1-\gamma)\mu^*) + (1-\varphi)(1-\gamma)\mu^*)((1-\delta)\varphi + (1-\varphi)(1-\gamma))} > 0, \end{aligned}$$

which proves the lemma. \square

A.20. Proof of Proposition 7

If VCs are profit-motivated, there is a market breakdown whenever

$$\tau_{\text{PM}} := (1-\delta)\varphi\text{NPV}_g + (1-\varphi)(1-\gamma)\text{NPV}_b < 0. \quad (\text{A.97})$$

Observe that the condition in the proposition (equation (23)) is exactly the condition for $\tau_{\text{PM}} < 0$, so there is always a market breakdown if the VC is profit motivated. Hence, when this condition is satisfied, productive efficiency is zero

in the profit-motivation equilibrium. This immediately implies that productive efficiency is weakly higher in the reputation-motivation equilibrium, since productive efficiency is never negative. I now show that productive efficiency can be strictly higher, since there are parameters satisfying this condition for which there is not a market breakdown with reputation motivation. In particular, if the VC is reputation-motivated, there is a market breakdown whenever

$$\tau_{RM} := (1 - \delta)\varphi(\gamma + (1 - \gamma)\mu^*)NPV_g + (1 - \varphi)(1 - \gamma)\mu^*NPV_b < 0. \tag{A.98}$$

The result thus follows from the fact that $\tau_{RM} > \tau_{PM}$:

$$\begin{aligned} \tau_{RM} - \tau_{PM} &= -(1 - \delta)\varphi(1 - \gamma)(1 - \mu^*)NPV_g \\ &\quad - (1 - \varphi)(1 - \gamma)(1 - \mu^*)NPV_b > 0 \end{aligned} \tag{A.99}$$

whenever inequality (23) is satisfied. □

A.21. Proof of Proposition 8

The proof of this proposition is analogous to that of Proposition 2, which characterizes the reputation-motivation equilibrium. The only substantive difference is that the reputation-motivated VC’s payoff is a nonlinear function of its beliefs. I outline only the points of departure from that proof.

Beliefs. For a given mixing probability μ of the unskilled VC, the expressions are the same as those characterized in Proposition 2.

Unskilled VC. I consider three possible cases.

(i) *The unskilled VC always backs the firm.* $\mu^\kappa = 1$ is an equilibrium if

$$\mathbb{E}[\Pi_{RM}^u(a = 1)] \geq \mathbb{E}[\Pi_{RM}^u(a = 0)], \tag{A.100}$$

or

$$\varphi \left[\frac{\gamma}{\gamma + (1 - \gamma)\mu} \right]^\kappa \geq \left[\frac{(1 - \varphi)\gamma}{(1 - \varphi)\gamma + (1 - \gamma)(1 - \mu)} \right]^\kappa, \tag{A.101}$$

when $\mu = 1$. This reduces to

$$\varphi^{1/\kappa} \gamma \geq 1, \tag{A.102}$$

which is never satisfied for $\kappa > 0$. Thus, it must be the case that $\mu^\kappa < 1$.

(ii) *The unskilled VC never backs a firm.* $\mu^\kappa = 0$ is an equilibrium if

$$\mathbb{E}[\Pi_{RM}^u(a = 1)] \leq \mathbb{E}[\Pi_{RM}^u(a = 0)], \tag{A.103}$$

or

$$\varphi \left[\frac{\gamma}{\gamma + (1 - \gamma)\mu} \right]^\kappa \leq \left[\frac{(1 - \varphi)\gamma}{(1 - \varphi)\gamma + (1 - \gamma)(1 - \mu)} \right]^\kappa, \tag{A.104}$$

when $\mu = 0$. This reduces to

$$\gamma \geq \frac{\varphi^{1/\kappa}}{1 - \varphi + \varphi^{1+1/\kappa}}. \tag{A.105}$$

Thus, $\mu^\kappa = 0$ is an equilibrium if and only if $\gamma \geq \frac{\varphi^{1/\kappa}}{1 - \varphi + \varphi^{1+1/\kappa}} =: \gamma^k$.

(iii) *The unskilled VC backs a firm with probability $\mu \in (0, 1)$. $\mu^\kappa \in (0, 1)$ is an equilibrium if*

$$\mathbb{E}[\Pi_{RM}^u(a = 1)] = \mathbb{E}[\Pi_{RM}^u(a = 0)] \tag{A.106}$$

or

$$\varphi \left[\frac{\gamma}{\gamma + (1 - \gamma)\mu} \right]^\kappa = \left[\frac{(1 - \varphi)\gamma}{(1 - \varphi)\gamma + (1 - \gamma)(1 - \mu)} \right]^\kappa. \tag{A.107}$$

This reduces to

$$\mu^\kappa = \frac{\gamma\varphi(1 - \varphi^{1/\kappa}) - \gamma + \varphi^{1/\kappa}}{(1 - \gamma)(1 - \varphi + \varphi^{1/\kappa})}. \tag{A.108}$$

This expression is between zero and one as long as the condition in equation (A.105) is violated, or $\gamma \in [0, \gamma^k)$, which is satisfied by hypothesis. \square

Bound for μ^κ . Before proceeding with the proof, it is useful to establish the following lemma.

LEMMA A4: *If there is an interior μ^κ in equation (A.108), we have that*

$$\mu^* < \mu^\kappa \tag{A.109}$$

if and only if $\kappa > 1$ and

$$\mu^\kappa < \frac{1}{2 - \varphi}, \tag{A.110}$$

whenever $\kappa > 0$.

PROOF: The proof is by direct computation. From equations (A.12) and (A.108) above, we have that

$$\mu^* - \mu^\kappa = \frac{(1 + \gamma(1 - \varphi))(1 - \varphi)(\varphi - \varphi^{1/\kappa})}{(1 - \gamma)(1 - \varphi + \varphi^{1/\kappa})} < 0, \tag{A.111}$$

since $1 - \varphi + \varphi^{1/\kappa} > 0$ for $\kappa > 0$ and $\varphi < \varphi^{1/\kappa}$ if and only if $\kappa > 1$. This proves the inequality in equation (A.109).

From equation (A.108) above, we have that

$$\mu^\kappa - \frac{1}{2 - \varphi} = -\frac{(1 + \gamma(1 - \varphi))(1 - \varphi)(1 - \varphi^{1/\kappa})}{(1 - \gamma)(2 - \varphi)(1 - \varphi + \varphi^{1/\kappa})} \leq 0, \tag{A.112}$$

since $1 \geq \varphi^{1/\kappa}$ and $1 - \varphi + \varphi^{1/\kappa} > 0$ for $\kappa > 0$. This proves the inequality in equation (A.110).

Skilled VC. The positively informed VC backs the firm if

$$\mathbb{E}[\Pi_{\text{RM}}^s(a = 1, \theta = g)] \geq \mathbb{E}[\Pi_{\text{RM}}^s(a = 0, \theta = g)], \quad (\text{A.113})$$

or

$$\left[\frac{\gamma}{\gamma + (1 - \gamma)\mu^\kappa} \right]^\kappa \geq \left[\frac{(1 - \varphi)\gamma}{(1 - \varphi)\gamma + (1 - \gamma)(1 - \mu^\kappa)} \right]^\kappa. \quad (\text{A.114})$$

This inequality reduces to $\mu^\kappa < 1/(2 - \varphi)$, which is satisfied by Lemma A4 above.

The negatively informed VC does not back the firm if

$$\mathbb{E}[\Pi_{\text{RM}}^s(a = 0, \theta = b)] \geq \mathbb{E}[\Pi_{\text{RM}}^s(a = 1, \theta = b)], \quad (\text{A.115})$$

or

$$\left[\frac{(1 - \varphi)\gamma}{(1 - \varphi)\gamma + (1 - \gamma)(1 - \mu^\kappa)} \right]^\kappa \geq 0. \quad (\text{A.116})$$

This inequality is always satisfied.

Bidders. Following from Lemma 1, the IPO succeeds if

$$\frac{\varphi\gamma V_g + (1 - \gamma)\mu^\kappa \bar{V}}{\varphi\gamma + (1 - \gamma)\mu^\kappa} > I. \quad (\text{A.117})$$

There are now two cases to be considered: (i) $\gamma \geq \gamma^k$, so $\mu^\kappa = 0$, and (ii) $\gamma < \gamma^k$, so $\mu^\kappa = \frac{\gamma\varphi(1 - \varphi^{1/\kappa}) - \gamma + \varphi^{1/\kappa}}{(1 - \gamma)(1 - \varphi + \varphi^{1/\kappa})}$.

In case (i), inequality (A.117) can be rewritten as

$$\varphi\gamma \text{NPV}_g > 0, \quad (\text{A.118})$$

which is always satisfied.²⁸

In case (ii), inequality (A.117) is satisfied whenever

$$\varphi\gamma \text{NPV}_g + \frac{\varphi^{1/\kappa} - \gamma(1 - \varphi + \varphi^{1+1/\kappa})}{1 - \varphi + \varphi^{1/\kappa}} \overline{\text{NPV}} > 0. \quad (\text{A.119})$$

This is the condition given in the statement of the proposition. □

Given the equilibrium behavior of the skilled VC and bidders coincides with the baseline model, Lemma A4, which says that $\mu^* < \mu^\kappa$ if and only if $\kappa > 1$, establishes the proposition. □

²⁸ Note that $\gamma > 0$ and $\varphi > 0$ by Parameter Restriction 1 and $V_b < 0$.

A.22. Proof of Lemma 10

Consider an equilibrium in which all types of profit-motivated VCs back the firm. Then, the expected value of the firm conditional on $\alpha = 1$ is

$$\mathbb{E}[V_\theta | \alpha = 1] = \bar{V}. \quad (\text{A.120})$$

Bidders. By Lemma 1, the IPO succeeds if the conditional expected value of the firm exceeds I , or

$$\bar{V} > I. \quad (\text{A.121})$$

This is equivalent to the condition in the proposition.

Skilled VC. If the VC is skilled, then its payoff is $(1 - \alpha)V_\theta$. Since $0 < \alpha < 1$ and $V_g > V_b > 0$, both the positively informed VC and the negatively informed VC back the firm.

Unskilled VC. If the VC is unskilled, then its payoff is $(1 - \alpha)\bar{V}$. Since $0 < \alpha < 1$ and $\bar{V} > 0$, the unskilled VC backs the firm. \square

A.23. Proof of Lemma 11

Profit-Motivation Equilibrium. Suppose there exists an equilibrium in which the VC's behavior is as described in Proposition 1. I must verify that it is indeed an equilibrium if $V_b > 0$ and the profit-motivated VC's payoff is as in equation (27).

Bidders. Following Lemma 1, the IPO succeeds if

$$\frac{\varphi\gamma V_g + (1 - \gamma)\bar{V}}{\varphi\gamma + 1 - \gamma} > I. \quad (\text{A.122})$$

If this condition is not satisfied, firm value is not realized and VCs will not provide initial capital c to the firm. If this condition is satisfied, the IPO succeeds and I can solve for α from the bidders' break-even condition in equation (5):

$$\alpha = \frac{(\varphi\gamma + 1 - \gamma)I}{\varphi\gamma V_g + (1 - \gamma)\bar{V}}. \quad (\text{A.123})$$

Unskilled VC. I now verify that the unskilled VC prefers to back the firm rather than not to back the firm. From equation (27), the unskilled VC's expected payoff if it backs the firm is

$$\mathbb{E}[\Pi_{\text{PM}}^\alpha] = (1 - \alpha)\bar{V} - c = \frac{\varphi\gamma \text{NPV}_g + (1 - \gamma)\overline{\text{NPV}}}{\varphi\gamma V_g + (1 - \gamma)\bar{V}} \bar{V} - c, \quad (\text{A.124})$$

having substituted for α from equation (A.123). If this is positive, the unskilled VC backs the firm.

Positively Informed VC. The no-deviation condition for the positively informed VC follows immediately from the no-deviation condition for the

unskilled VC. This is because the positively informed VC's payoff is always higher, since it knows that it will receive $(1 - \alpha)V_g - c > (1 - \alpha)\bar{V} - c$.

Negatively Informed VC. The negatively informed VC must prefer not to back the firm to backing the firm. Its expected payoff from backing is

$$\mathbb{E}[\Pi_{PM}^u] = \frac{\varphi\gamma NPV_g + (1 - \gamma)\overline{NPV}}{\varphi\gamma V_g + (1 - \gamma)\bar{V}} V_b - c. \tag{A.125}$$

If this is negative, it prefers not to back the firm.

Reputation-Motivation Equilibrium. Since the payoff of the reputation-motivated VC does not depend on profits, it is not affected by the addition of the upfront cost c . Thus, its behavior is unchanged. \square

A.24. Proof of the Proposition 9

I begin by pointing out that the skilled VCs behave exactly as in the baseline model. I then look at the behavior of the unskilled VCs, first in the profit-motivation equilibrium and then in the reputation-motivation equilibrium.

Skilled VCs. In both the profit-motivation and reputation-motivation equilibria, the incentives of the skilled VCs are as in the baseline model. Their behavior is unchanged: the positively informed skilled VC backs the firm and the negatively informed skilled VC does not.

Unskilled Profit-Motivated VC. Here, the unskilled VC knows σ privately. It backs a firm whenever

$$(1 - \alpha)\mathbb{E}[\sigma V_g + (1 - \sigma)V_b \mid \sigma] \geq 0, \tag{A.126}$$

or

$$\sigma \geq -\frac{V_b}{V_g - V_b}. \tag{A.127}$$

This always holds by Parameter Restriction 1' and thus the unskilled profit-motivated VC always backs a firm.

Unskilled Reputation-Motivated VC. The market observes the VC's action a and, if the IPO succeeds, it also observes the long-run realized value of the firm V_θ . Given this information, it updates its beliefs about the VC's type. Given the beliefs that the unskilled VC backs the firm whenever $\sigma \geq \hat{\sigma}_{RM}$, the application of Bayes's rule gives the following posterior beliefs about the VC's type:

$$\mathbb{P}[s \mid V_\theta, a] = \begin{cases} 0 & \text{if } V_\theta = V_b \text{ and } a = 1, \\ \frac{(1-\varphi)\gamma}{(1-\varphi)\gamma + (1-\gamma)\frac{\hat{\sigma}_{RM}-a}{1-a}} & \text{if } a = 0, \\ \frac{\gamma}{\gamma + (1-\gamma)\frac{1-\hat{\sigma}_{RM}}{1-a}} & \text{if } V_\theta = V_g \text{ and } a = 1. \end{cases}$$

Thus, we can compute the unskilled VC's payoff if it backs the firm and if it does not back the firm as follows. If it backs, its payoff is

$$\mathbb{E}[\Pi_{\text{RM}}^u(a=1)|\sigma] = \sigma \left[\frac{\gamma}{\gamma + (1-\gamma)\frac{1-\hat{\sigma}_{\text{RM}}}{1-\underline{\sigma}}} \right], \quad (\text{A.128})$$

and if it does not, its payoff is

$$\mathbb{E}[\Pi_{\text{RM}}^u(a=0)|\sigma] = \frac{(1-\varphi)\gamma}{(1-\varphi)\gamma + (1-\gamma)\frac{\hat{\sigma}_{\text{RM}}-\underline{\sigma}}{1-\underline{\sigma}}}. \quad (\text{A.129})$$

At the threshold $\sigma = \hat{\sigma}_{\text{RM}}$, the unskilled VC must be indifferent between backing and not backing the firm. Substituting for $\varphi = \frac{1+\sigma}{2}$, $\hat{\sigma}_{\text{RM}}$ solves

$$2(1-\gamma)\hat{\sigma}_{\text{RM}}^2 + (1-(3-\gamma)\underline{\sigma} + \gamma\underline{\sigma}^2)\hat{\sigma}_{\text{RM}} - (1-\underline{\sigma})(1-\gamma\underline{\sigma}) = 0. \quad (\text{A.130})$$

By standard arguments, this equation has only one positive root,²⁹

$$\begin{aligned} \hat{\sigma}_{\text{RM}} = & \frac{-(1-(3-\gamma)\underline{\sigma} + \gamma\underline{\sigma}^2)}{4(1-\gamma)} + \\ & + \frac{\sqrt{(1-(3-\gamma)\underline{\sigma} + \gamma\underline{\sigma}^2)^2 + 8(1-\gamma)(1-\underline{\sigma})(1-\gamma\underline{\sigma})}}{4(1-\gamma)}. \end{aligned} \quad (\text{A.131})$$

Thus, the unskilled reputation-motivated VC backs the firm whenever $\sigma \geq \hat{\sigma}_{\text{RM}}$.

With a few lines of calculation, we can find that $\hat{\sigma}_{\text{RM}} > \underline{\sigma}$ whenever

$$8(1-\gamma)(1-\underline{\sigma})^2(1-\gamma\underline{\sigma}) \geq 0, \quad (\text{A.132})$$

which always holds. □

A.25. Proof of Corollary 5

To prove the corollary, first compute

$$\begin{aligned} \frac{\partial \hat{\sigma}_{\text{RM}}}{\partial \gamma} = & \frac{(1-\underline{\sigma})^2}{4(1-\gamma)^2} \\ & \times \left(\frac{5-4\gamma-3\underline{\sigma} + \gamma\underline{\sigma} + \gamma\underline{\sigma}^2}{\sqrt{(1-(3-\gamma)\underline{\sigma} + \gamma\underline{\sigma}^2)^2 + 8(1-\gamma)(1-\underline{\sigma})(1-\gamma\underline{\sigma})}} - 1 \right). \end{aligned} \quad (\text{A.133})$$

With a few lines of calculation, we find that $\partial \hat{\sigma}_{\text{RM}}/\partial \gamma > 0$ whenever

$$16(1-\gamma)^2(1-\underline{\sigma}) > 0, \quad (\text{A.134})$$

which always holds. □

²⁹ Recall that, in general, a quadratic equation $a_2x^2 + a_1x + a_0 = 0$ has at most one positive root if $a_0a_2 < 0$, which is the case here.

A.26. Formalization of the Statement in Footnote 16

Here, I allow the VC to choose the size of the stake α it sells, and I spell out why there is an equilibrium in which the VC retains the largest possible stake.

If the VC can choose the size of the stake α it sells, then IPO bidders condition their beliefs on α . Hence, their break-even condition is

$$\alpha \mathbb{E}[V_\theta | \alpha = 1, \alpha] \geq I. \tag{A.135}$$

Denoting the size of the stake issued in the baseline model by α^* , this inequality binds with $\alpha = \alpha^*$ (see equation (A.2) for the profit-motivation equilibrium and equation (A.20) for the reputation-motivation equilibrium). Now suppose that the off-equilibrium beliefs are such that for any $\alpha \neq \alpha^*$,

$$\mathbb{P}[\theta = b | \alpha = 1, \alpha] = 1, \tag{A.136}$$

so

$$\mathbb{E}[V_\theta | \alpha = 1, \alpha] = V_b. \tag{A.137}$$

Since $V_b < 0$, it is immediate that if the VC deviates to $\alpha \neq \alpha^*$, it cannot raise I (in neither the profit-motivation equilibrium nor the reputation-motivation equilibrium). Hence, it chooses $\alpha = \alpha^*$ in equilibrium (and the off-equilibrium beliefs remain off equilibrium and hence are consistent).

This equilibrium is not unique, and depends on the off-equilibrium beliefs I impose. However, focusing on the profit-motivation equilibrium, I argue that this is the “right” equilibrium. Specifically, I argue that these off-equilibrium beliefs are reasonable in the sense that the “high types,” that is, the skilled positively informed VCs, have the least incentive to deviate to retain a smaller stake. Indeed, it is easy to see that the “high type” of VC has the most to gain from retaining a large stake. Since it knows it has a good quality firm, its payoff is

$$(1 - \alpha)V_g + \alpha \mathbb{E}[V_\theta | \alpha = 1, \alpha] - I, \tag{A.138}$$

whereas, since the unskilled VC has an average quality firm, its payoff is

$$(1 - \alpha)(\varphi V_g + (1 - \varphi)V_b) + \alpha \mathbb{E}[V_\theta | \alpha = 1, \alpha] - I. \tag{A.139}$$

Taking the difference between the two expressions above, we see that the gains of the skilled positively informed VC over the unskilled VC are

$$(1 - \alpha)(1 - \varphi)(V_g - V_b), \tag{A.140}$$

which is increasing in $1 - \alpha$, the stake retained by the VC, that is, the “high-type” VC has the most to gain from retaining a large stake. Hence, these off-equilibrium beliefs are reasonable in a sense akin to the intuitive criterion. \square

REFERENCES

- Banks, Jeffrey S., and Joel Sobel, 1987, Equilibrium selection in signaling games, *Econometrica* 55, 647–661.
- Bond, Philip, and Itay Goldstein, 2015, Government intervention and information aggregation by prices, *The Journal of Finance* 70, 2777–2812.
- Bond, Philip, Itay Goldstein, and Edward Simpson Prescott, 2010, Market-based corrective actions, *Review of Financial Studies* 23, 781–820.
- Boot, Arnoud W. A., and Anjan V. Thakor, 1997, Banking scope and financial innovation, *Review of Financial Studies* 10, 1099–1131.
- Booth, James R., and Richard Smith, 1986, Capital raising, underwriting and the certification hypothesis, *Journal of Financial Economics* 15, 261–281.
- Chemmanur, Thomas J., and Paolo Fulghieri, 1994, Investment bank reputation, information production, and financial intermediation, *Journal of Finance* 49, 57–79.
- Chen, Ying, 2015, Career concerns and excessive risk taking, *Journal of Economics and Management Strategy* 24, 110–130.
- Chevalier, Judith, and Glenn Ellison, 1999, Career concerns of mutual fund managers, *Quarterly Journal of Economics* 114, 389–432.
- Cho, In-Koo, and David M. Kreps, 1987, Signaling games and stable equilibria, *Quarterly Journal of Economics* 102, 179–222.
- Crain, Nicholas, 2016, Venture capital and career concerns, Research paper no. 2517640, Vanderbilt Owen Graduate School of Management Research.
- Dasgupta, Amil, and Giorgia Piacentino, 2015, The Wall Street walk when blockholders compete for flows, *Journal of Finance* 70, 2853–2896.
- Dasgupta, Amil, and Andrea Prat, 2006, Financial equilibrium with career concerns, *Theoretical Economics* 1, 67–93.
- Dasgupta, Amil, and Andrea Prat, 2008, Information aggregation in financial markets with career concerns, *Journal of Economic Theory* 143, 83–113.
- Donaldson, Jason, Giorgia Piacentino, and Anjan Thakor, 2019, Intermediation variety, Working paper, Washington University in St. Louis.
- Dow, James, Itay Goldstein, and Alexander Guembel, 2016, Incentives for information production in markets where prices affect real investment, *Journal of the European Economic Association* 126, 877–909.
- Dow, James, and Gary Gorton, 1997, Noise trading, delegated portfolio management, and economic welfare, *Journal of Political Economy* 105, 1024–1050.
- Dow, James, and Rohit Rahi, 2003, Informed trading, investment, and welfare, *Journal of Business* 76, 439–454.
- Edmans, Alex, Itay Goldstein, and Wei Jiang, 2015, Feedback effects, asymmetric trading, and the limits to arbitrage, *American Economic Review* 105, 3766–3797.
- Fama, Eugene F., 1980, Agency problems and the theory of the firm, *Journal of Political Economy* 88, 288–307.
- Fulghieri, Paolo, and Dimitry Lukin, 2001, Information production, dilution costs, and optimal security design, *Journal of Financial Economics* 61, 3–42.
- Gibbons, Robert, and Kevin J. Murphy, 1992, Optimal incentive contracts in the presence of career concerns: Theory and evidence, *Journal of Political Economy* 100, 468–505.
- Goldstein, Itay, and Alexander Guembel, 2008, Manipulation and the allocational role of prices, *Review of Economic Studies* 75, 133–164.
- Goldstein, Itay, and Liyan Yang, 2014, Market efficiency and real efficiency: The connect and disconnect via feedback effects, Working paper, Wharton Business School.
- Gompers, Paul, 1995, Optimal investment, monitoring, and the staging of venture capital, *Journal of Finance* 50, 1461–1489.
- Gompers, Paul, 1996, Grandstanding in the venture capital industry, *Journal of Financial Economics* 42, 133–156.

- Gompers, Paul, Anna Kovner, Josh Lerner, and David Scharfstein, 2006, Skill vs. luck in entrepreneurship and venture capital: Evidence from serial entrepreneurs, NBER Working Paper 12592.
- Gompers, Paul, and Josh Lerner, 1998, Venture capital distributions: Short-run and long-run reactions, *Journal of Finance* 53, 2161–2183.
- Gompers, Paul, and Josh Lerner, 1999a, An analysis of compensation in the U.S. venture capital partnership, *Journal of Financial Economics* 51, 3–44.
- Gompers, Paul, and Josh Lerner, 1999b, What drives venture capital fundraising?, NBER Working Paper 6906.
- Gompers, Paul A., Will Gornall, Steven N. Kaplan, and Ilya A. Strebulaev, 2016, How do venture capitalists make decisions?, ECGI Finance Working Paper N° 477/2016.
- Guerrieri, Veronica, and Péter Kondor, 2012, Fund managers, career concerns, and asset price volatility, *American Economic Review* 102, 1986–2017.
- Hirshleifer, David, and Anjan Thakor, 1994, Managerial performance, boards of directors and takeover bidding, *Journal of Corporate Finance* 1, 63–90.
- Hölmstrom, Bengt, 1999, Managerial incentive problems: A dynamic perspective, *The Review of Economic Studies* 66, 169–182.
- Hölmstrom, Bengt, and Joan Ricart i Costa, 1986, Managerial incentives and capital management, *Quarterly Journal of Economics* 101, 835–860.
- Hsu, David H., 2004, What do entrepreneurs pay for venture capital affiliation?, *Journal of Finance* 59, 1805–1844.
- Inderst, Roman, Holger M. Mueller, and Felix Münnich, 2007, Financing a portfolio of projects, *Review of Financial Studies* 20, 1289–1325.
- Jovanovic, Boyan, and Balázs Szentes, 2013, On the market for venture capital, *Journal of Political Economy* 121, 493–527.
- Kaplan, Steven N., and Josh Lerner, 2010, It ain't broke: The past, present, and future of venture capital, *Journal of Applied Corporate Finance* 22, 36–47.
- Kaplan, Steven N., and Antoinette Schoar, 2005, Private equity performance: Returns, persistence, and capital flows, *Journal of Finance* 60, 1791–1823.
- Khanna, Naveen, and Richmond Matthews, 2017, The limits of reputation, Working paper, Michigan State University and the University of Maryland.
- Krishnan, C. N. V., Vladimir I. Ivanov, Ronald W. Masulis, and Ajai K. Singh, 2011, Venture capital reputation, post-IPO performance, and corporate governance, *Journal of Financial and Quantitative Analysis* 46, 1295–1333.
- Lee, Peggy M., and Sunil Wahal, 2004, Grandstanding, certification and the underpricing of venture capital backed IPOs, *Journal of Financial Economics* 73, 375–407.
- Meggison, William L., and Kathleen A. Weiss, 1991, Venture capitalist certification in initial public offerings, *Journal of Finance* 46, 879–903.
- Milbourn, Todd T., Richard L. Shockley, and Anjan V. Thakor, 2001, Managerial career concerns and investments in information, *RAND Journal of Economics* 32, 334–351.
- Nahata, Rajarishi, 2008, Venture capital reputation and investment performance, *Journal of Financial Economics* 90, 127–151.
- Nelson, Hal, Fred Wainwright, and Colin Blaydon, 2004, Note on due diligence in venture capital, Tuck School of Business at Dartmouth Case 5-0014.
- Prendergast, Canice, and Lars Stole, 1996, Impetuous youngsters and jaded old-timers: Acquiring a reputation for learning, *Journal of Political Economy* 104, 1105–1134.
- Puri, Manju, and Rebecca Zarutskie, 2012, On the life cycle dynamics of venture-capital- and non-venture-capital-financed firms, *Journal of Finance* 67, 2247–2293.
- Ramsinghani, Mahendra, 2014, *The Business of Venture Capital: Insights from Leading Practitioners on the Art of Raising a Fund, Deal Structuring, Value Creation, and Exit Strategies* (Wiley, Hoboken, NJ).
- Rock, Kevin, 1986, Why new issues are underpriced, *Journal of Financial Economics* 15, 187–212.
- Scharfstein, David S., and Jeremy C. Stein, 1990, Herd behavior and investment, *American Economic Review* 80, 465–479.

- Sørensen, Morten, 2007, How smart is smart money? A two-sided matching model of venture capital, *Journal of Finance* 62, 2725–2762.
- Subrahmanyam, Avanidhar, and Sheridan Titman, 2001, Feedback from stock prices to cash flows, *Journal of Finance* 56, 2389–2413.
- Thornton, Grant, 2014, A time of challenge and opportunity. Available at https://www.grantthornton.global/globalassets/1.-member-firms/global/insights/article-pdfs/2013/global_private_equity_report_2013.pdf.
- Zwiebel, Jeffrey, 1995, Corporate conservatism and relative compensation, *Journal of Political Economy* 103, 1–25.