VENTURE CAPITAL AND CAPITAL ALLOCATION*

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Abstract

In this paper, I show that venture capitalists' career concerns can have beneficial effects in the primary market: they can mitigate information frictions, helping firms go public. Because uninformed VCs want to appear informed, they are biased against backing firms—by not backing firms, VCs avoid taking low-value firms to market, which would ultimately reveal their lack of information. In equilibrium, VCs back only high-value firms, creating a certification effect that mitigates information frictions, helping firms go public. However, this benefit comes at the cost that VCs inefficiently do not back some high-value firms.

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1 Introduction

Delegated investors wish to be perceived as skilled in order to generate "flows," i.e., to attract new investors and retain existing ones. These *career concerns* can distort their trades in secondary markets. For example, delegated investors may trade too much in the attempt to appear informed, even when they are not. This excessive portfolio churning can, in turn, decrease secondary market efficiency (Dasgupta and Prat (2006, 2008), Dow and Gorton (1997), and Guerrieri and Kondor (2012)). However, delegated investors do not only play an important role 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 funds (VCs) decide which firms to back and thus which projects go ahead. Therefore, I ask: Do VCs' career concerns lead to inefficiencies in primary markets? Specifically, do career-concerned VCs back the wrong firms in the attempt to appear skilled?

In this paper, I develop a model to address these questions. I show that career-concerned VCs act conservatively. Specifically, uninformed career-concerned VCs pass up backing new firms even when they believe that doing so would probably be profitable. Indeed, they do not want to risk taking bad firms to market, as this could reveal their lack of information. Hence, to appear informed and appeal to investors, uninformed VCs underinvest, thereby acting against these investors' interests. However, these individually inefficient actions can be socially efficient. The reason is that they can mitigate information frictions that may exist at the time of IPO. Since career-concerned VCs are conservative, they back only the best firms, and thus create a "certification effect" that helps firms IPO. However, this benefit comes at the cost that VCs inefficiently do not back some high-value firms.

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, i.e., 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 IPO, in which the VC retains its stake. 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, but if it is unskilled it observes nothing. I consider two cases. First, the VC may be *profit motivated*, i.e., it wants to back the firm whenever it expects to make a profit for its current investors. Second, the VC may be *career concerned*, i.e., 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. Thus, it does not back bad firms and it backs good firms as long as it anticipates being able to take them IPO. Hence, a skilled VC "filters out" bad firms. In contrast, an unskilled VC does not know whether the firm is good or bad. However, 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—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. This maximizes its expected profit, but may be socially inefficient. Indeed, the unskilled VC over-invests, and may still back a firm with negative NPV. When the average NPV is low enough, the unskilled VC's over-investment 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—i.e., the collapse of the IPO market causes the VC market to break down.

What changes if the VC is career-concerned? Now, 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. Indeed, 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 it wrongly rejected a good firm. To put it another way, 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," i.e., toward not backing the firm. In other words, the unskilled VC acts conservatively.

When the unskilled career-concerned VC rejects a firm, it may act against the interests of its investors. Indeed, if it were only to maximize profits for its investors, it would want to act exactly like the unskilled profit-motivated VC, backing the firm to take advantage of the IPO subsidy from the skilled VC. However, this underinvestment can enhance aggregate efficiency. It leads to a certification effect of VC backing that can prevent market breakdowns: since unskilled career-concerned VCs back the firm relatively rarely, many VC-backed firms are backed by positively informed skilled VCs; therefore, the market infers that the VC-backed firms are probably good. This certification effect mitigates information frictions to help firms IPO.

Even absent market breakdowns, VCs' career concerns can lead to an increase in aggregate efficiency. Since the unskilled VC has no information, it backs firms of average value. If this average NPV is negative, aggregate efficiency is higher with career-concerned VCs, given they back firms less often than profit-motivated VCs. However, if this average NPV is positive, aggregate efficiency is lower with career-concerned VCs, since, in this case, the costs of backing fewer good firms outweigh the benefits of backing fewer bad firms. Below, I place more emphasis on the negative-NPV case, and hence on the positive effects of career concerns, because I think this case is realistic: VC partners "source a few thousand opportunities, invest in a handful, and get returns from a few"; in fact "almost 80 percent of all investments fail" (Ramsinghani (2014), p. 69 and p. 6).

Extensions and robustness. I show that the positive side of career concerns is robust to a number of extensions. 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, but attenuated. The results are also qualitatively similar, but amplified, if either (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, or (iv) there is adverse selection among IPO investors, so that the firm must issue shares at a discount to induce uninformed investors to participate. Further, I show that my main results are robust to relaxing some of the other simplifying assumptions I make in the baseline model.

Layout. The paper proceeds as follows. Next, I discuss the model's empirical relevance and some related literature. In Section 2, I present the model. In Section 3, I characterize the equilibria, both for profit-motivated and career-concerned VCs. In Section 4, I compare these equilibria and show that career concerns increase IPO prices, prevent market breakdowns, and increase aggregate output for some parameters. In Section 5, I consider extensions and show that the model is robust to a number of different specifications. I conclude in Section 6. The Appendix contains the proofs and the equilibrium refinements.

1.1 Realism and Empirical Content

Assumptions. My model is based on the assumption that VCs are career concerned, in the sense that they have incentive to appear skilled in order to attract capital from new investors. This assumption reflects practice. VCs' revenues are based largely on the amount of capital they manage (see Subsection 2.4) and VCs' investors invest with VCs based on their past performance (see, for example, Gompers and Lerner (1998, 2001)). 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, e.g., Gompers, Kovner, Lerner, and Scharfstein (2006)).

Proxies. To compare my model with empirical findings, the challenge is to find proxies for VCs' career concerns. In the model, VCs' career concerns reflect three components: career-concerned VCs value highly (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. Each of these components finds natural proxies: (i) career-concerned VCs are younger,[1] (ii) career-concerned VCs have higher fixed fees relative to performance fees (so they need to increase assets under management to increase revenue),[2] (iii) career-concerned VCs are large (manage a lot of capital)[3] and have strong track records.[4] More generally, the career-concerned VCs in my model could correspond to real-world venture capital 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 non-delegated primary market investors that do not compete for flows.

Consistent stylized facts. In light of the proxies for career concerns discussed above, my model is consistent with a number of empirical findings. First, my result that more career-concerned VCs help to prevent market breakdowns is consistent with the finding that VCs are more likely to lead their portfolio companies to successful IPOs (Krishnan, Ivanov, Masulis, and Singh (2011) and Nahata (2008)). Second, my result that more career-concerned VCs increase the IPO price is consistent with the empirical findings that (i) VC-backed firms are less likely to be underpriced at IPO (Barry, Muscarella, Peavy, Megginson and Weiss (1991) and Vetsuypens (1990)) and, further, (ii) this underpricing is decreasing in the strength of the reputation of the VC backing the firm (see Gompers (1996)). 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) and 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).

New predictions. The main new prediction of my model is that more career-concerned VCs back firms relatively less often, but back higher-quality firms. Thus, career concerns predict higher IPO prices (less underpricing) and fewer IPOs in normal times (because career-concerned VCs back fewer firms), but possibly more IPOs in downturns (because career concerns prevent market breakdowns when firms have negative average NPV). The proxies described above make these predictions testable.

[1] Chevalier and Ellison (1999) use age as a proxy for mutual funds' career concerns. Gompers (1996) and Lee and Wahal (2004) use age as a proxy for VCs' career concerns.

[2] There is significant variation in VC compensation (see Subsection 2.4). VCs with a larger performance fee relative to the fixed fee are likely to be relatively less career concerned in comparison to VCs with a lower performance fee relative to the fixed fee (see Dasgupta and Piacentino (2015) for a discussion).

[3] Gompers (1998) and Gompers and Lerner (1999) use size as a proxy for reputation.

[4] See, for example, Krishnan, Ivanov, Masulis, and Singh (2011) and Sörensen (2007).

1.2 Related Literature

My main contribution to the literature is to show that the individually suboptimal behavior of career-concerned delegated investors can have positive aggregate effects in some circumstances. This contrasts with the literature in which career-concerned agents' "churning" has adverse effects (see Dasgupta and Prat (2006, 2008), Guerrieri and Kondor (2012), and Scharfstein and Stein (1990)).[5] Career concerns can help in my setup because they distort the actions of the unskilled VC in such a way that the actions of skilled positively informed VCs become more informative, thereby mitigating the inefficiencies that result from asymmetric information.[6]

This paper builds on a large literature on career concerns instigated by Fama (1980). Perhaps the most related paper in this literature is Chen (2015), which builds on the model in Hölmstrom (1999) to show that career-concerned agents tend to over-invest 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, e.g., Gibbons and Murphy (1992), Hölmstrom and Ricart i Costa (1986), and Scharfstein and Stein (1990), rather than to generate high output, the agent may underinvest.

Asymmetric learning about the agent's skill also appears in the career concerns models of Milbourn, Shockley, and Thakor (2001) and Hirshleifer and Thakor (1994). Milbourn, Shockley, and Thakor (2001) show that a career-concerned manager over-invests in information, because this improves the odds of rejecting a bad project. This makes him allocate capital correctly, but this decreases overall efficiency relative to first best. In my model, in contrast, the unskilled VC underinvests. The main driver of this contrasting result is that the agent (VC) knows its type in my model, but not in theirs. Hirshleifer and Thakor (1994) find that skilled managers are reluctant to undertake projects that might fail conspicuously.[7] Although I also find that career concerns lead to underinvestment, I find, in contrast, that this can increase aggregate efficiency. This is because the VC's decision feeds back into a real decision, i.e., the IPO bidders' choice to provide capital.

[5] 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.

[6] Other papers, following Hölmstrom (1999), have also found positive effects of reputation concerns. In these papers, reputation concerns mitigate the incentive problem between an agent and a principal—they provide implicit incentives that make up for lacking explicit incentives. Moreover, in Booth and Smith (1986) and Chemmanur and Fulghieri (1994), an underwriter's reputation concerns can mitigate the incentive problem between a firm raising capital (the agent) and a capital provider (the principal). In my paper, in contrast, reputation concerns *exacerbate* the incentive problem between the VC (the agent) and his client (the principal), but can still increase aggregate efficiency in equilibrium. Khanna and Matthews (2017) show another downside of VC reputation: high VC reputation can exacerbate a hold-up problem and lead good firms to loose VC backing.

[7] Such excessive "conservatism" is a common feature of career concerns models; see, e.g., Hölmstrom (1999), Prendergast and Stole (1996), and Zwiebel (1995).

Since the VC's decision to back the firm affects the firm's ability to IPO in my model, it is also related to papers on the feedback effects between financial 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 (forthcoming), Edmans, Goldstein, and Jiang (2015), Fulghieri and Lukin (2001), Goldstein and Guembel (2008), Goldstein and Yang (2014), and Subrahmanyam and Titman (2001).

2 Model

In this section, I present the model. In it, 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. After the IPO, the value of the firm is realized. Critically, the VC's incentives reflect *profit motivation* and *career concerns.*

2.1 Players

Firms. In my model economy, there is a firm that is of 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 NPV of a firm of type θ as $\text{NPV}_\theta := V_\theta - I$ and to the average NPV as $\overline{\text{NPV}} := \varphi V_g + (1-\varphi)V_b - I$. Finally, if the firm either fails to obtain backing from the VC or does not IPO successfully, it is worth zero.[8]

VCs. There is a VC that can be one of two types, denoted by s and u, where s stands for "skilled" and u for "unskilled." The VC is skilled with probability $\gamma \in (0, 1)$. 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.[9] Later, when the firm raises capital at the IPO, the VC

[8] The assumption that the firm has value zero 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 non-zero value in Subsection 5.1. The results are qualitatively the same as in the baseline model.

[9] 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, e.g., by buying at a high price. I abstract from this signaling problem mainly for simplicity. However, it is realistic that outsiders cannot observe many of the

retains its shares (although it is diluted by new shares).[10]

2.2 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.[11] These IPO bidders are uninformed; however, 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, i.e., $\iota = 0$ if either the VC does not back the firm or it backs the firm and the IPO fails.

2.3 Timeline

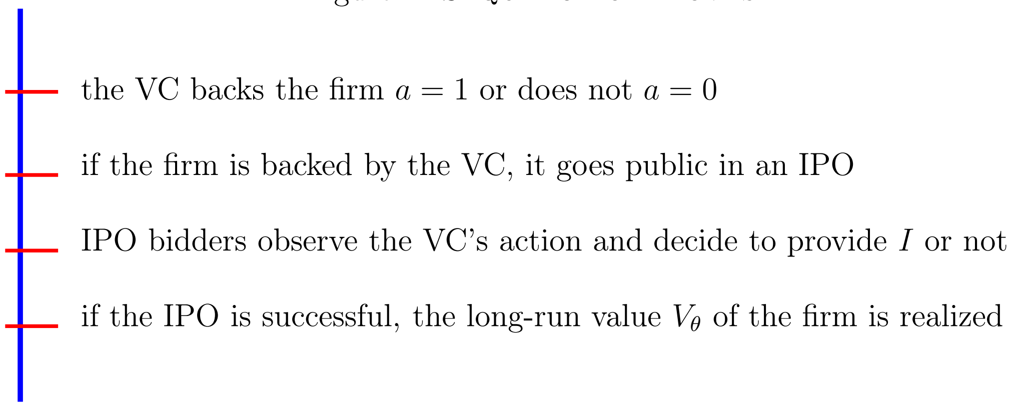
The sequence of moves is as follows. First, the VC either backs the firm, $a = 1$, or does not, $a = 0$. Second, if the VC has backed the firm, the firm may go public via an IPO. If IPO bidders provide I then the IPO is successful, $\iota = 1$. Otherwise, the IPO is unsuccessful, $\iota = 0$. Finally, 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.

terms of these deals, and hence a VC's ability to signal is limited.

[10]This is realistic, since VCs usually do not sell shares at the time of the IPO. Rather, they exit after a "lock-up" period of several months after the IPO. Further, VCs often continue to hold shares long after the lock-up period (see Gompers and Lerner (1998), p. 2164). Moreover, if I allowed VCs in the model to choose the size of the stake to keep at IPO, they would behave this way endogenously. (To be specific, there would be a pooling equilibrium in which all types of VCs retain the largest possible stake. Although this equilibrium is not unique, it is the best equilibrium for skilled VCs with good firms, who want to retain as much of their firms as possible to maximize the benefits of their private information; hence, it is "reasonable" in the spirit of Banks and Sobel's (1987) D1 criterion.) Nevertheless, in Subsection 5.2, I consider the variation of the model in which the VC exits at the IPO. My main results all go through in that setting.

[11]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, the largest fraction of the firm 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, since they require that a VC goes through the trouble of backing a firm knowing that it will never profit from it. This is a simple way to rule out these unappealing equilibria, without introducing a cost of VC backing/monitoring, which introduces more complication/notation.

Figure 1: Sequence of Moves



2.4 The VC's Payoff—Profit Motivation and Career Concerns

The VC's payoff takes different forms in different parts of the paper, reflecting the different preferences of real-world VCs. Today, 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 the net asset value and the variable portion is usually about 20% of profits (see Gompers and Lerner (1999)). Whereas the ability to make profits is key to obtaining the performance fee, the ability to build *reputation* is key to 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 below, in which the VC is (purely) profit motivated or (purely) career concerned. 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, i.e., to the fraction $1-\alpha$ of the firm that the VC holds after issuing α shares in the IPO:

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

If the VC is career concerned, I denote its payoff by Π_{CC}. In this case, its payoff reflects a VC's reputation, which is equal to the market's belief that a VC is skilled, given all available information:[12]

$$\Pi_{\text{CC}} = \mathbb{P}\left[\text{ skilled } \middle| \text{ public information }\right] = \mathbb{P}\left[s \,|\, a, \iota V_\theta\right]. \tag{2}$$

This expression says that a VC's reputation consists of the market's belief that the VC is skilled based on all observables: the VC's action a 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).[13]

Notation. Below, I sometimes differentiate between the payoffs of the skilled VC and the unskilled VC with superscripts s and u. Further, I sometimes indicate how the VC's payoff depends on its action and the type of the firm in parenthesis. For example, $\Pi^s_{\text{PM}}(a = 1, \theta = g)$ is the payoff of the skilled profit-motivated VC that backs ($a = 1$) a good firm ($\theta = g$).

2.5 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.

2.6 Parameter Restrictions

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

Parameter Restriction 1.

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

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

[13] The assumption that the market conditions its beliefs on both ιV_θ and a seems realistic. Anecdotal evidence from Grant Thornton's Global Equity Report (2016) suggests that VC investors do not look at only returns (not at only ιV_θ), 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, this assumption is not necessary for my results, since ιV_θ is sufficient to infer a in equilibrium—$\iota V_\theta = 0$ if and only if $a = 0$ (Proposition 1 and Proposition 2). Thus, my results also hold if the action a is private information and the market conditions its beliefs on returns alone.

Parameter Restriction 2.

$$V_b < 0. \tag{4}$$

Parameter Restriction 2 captures the idea that the VC's costs of monitoring and investments 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, i.e., V_θ represents the value of the firm net of these costs.[14] In Subsection 5.5, I relax the assumption that $V_b < 0$ and show that if $V_b > 0$ my results are amplified. However, restricting attention to $V_b < 0$ in the baseline analysis helps me to focus on the new economic mechanism in my paper.

3 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 career concerned. But, first, I solve 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.

3.1 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, i.e., if they provide capital then α solves

$$\alpha \mathbb{E}\left[V_\theta \,\middle|\, a = 1\right] = I. \tag{5}$$

Since, as discussed in Subsection 2.2, it must be 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. (IPO Success) *The IPO succeeds if and only if*

$$\mathbb{E}\left[V_\theta \,\middle|\, a = 1\right] > I. \tag{6}$$

3.2 Equilibrium Characterization with a Profit-motivated VC

In this subsection, I first characterize the equilibrium in which firms successfully IPO with a profit-motivated VC. I refer to this as the *profit-motivation equilibrium.* Then, I

[14] In Subsection 5.6, I model these costs explicitly to show that this reduced-form way of modeling them does not affect my results.

describe when the market breaks down, i.e., when there is no equilibrium in which the VC backs the firm.

Proposition 1. (Equilibrium Characterization with a Profit-motivated VC) *Suppose the VC is profit motivated. If*

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

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 $\overline{\mathrm{NPV}} < 0$. 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 incentive to over-invest, because it can sell over-priced shares in the IPO. This over-investment reduces the average quality of VC-backed firms. Indeed, the quality reduction from over-investment may be so severe that it causes the IPO market to break down entirely, as I describe in the following corollary.

Corollary 1. (Market Breakdown with a Profit-motivated VC) *Suppose the VC is profit motivated. If*

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

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 good 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.

3.3 Equilibrium Characterization with a Career-concerned VC

In this subsection, I first characterize the equilibrium in which firms successfully IPO with a career-concerned VC. I refer to this as the *career-concerns equilibrium.* Then, I describe when the market breaks down, i.e., when there is no equilibrium in which the IPO is successful.

PROPOSITION 2. (EQUILIBRIUM CHARACTERIZATION WITH A CAREER-CONCERNED VC) *Suppose the VC is career concerned. If either* $\gamma \geq \varphi/(1-\varphi+\varphi^2)$ *or*

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

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 career-concerns 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. On the other hand, the unskilled VC has the 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. (THE UNSKILLED VC IS CONSERVATIVE) *Consider the benchmark in which the firm's type is always revealed, i.e., the market learns the firm's type even if* $\iota = 0$*. The unskilled VC backs the firm less frequently in the career-concerns equilibrium in Proposition 2 than in this benchmark.*

So far, I have explained why the unskilled VC would choose not to back the firm—it allows it to pool with the skilled negatively informed VC. But why doesn't the unskilled VC 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 it was skilled for sure. This high upside payoff from backing the firm and being right can compensate for the risk 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. (Comparative statics on μ^*) *Given the equilibrium in Proposition 2, the probability μ^* with which the unskilled career-concerned 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.

Career concerns induce the unskilled VC not to back the firm; however, there may still be too much VC backing relative to first best in the career-concerns 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. (Market Breakdown with a Career-concerned VC) *Suppose the VC is career concerned. If $\gamma < \varphi/(1-\varphi+\varphi^2)$ and*

$$\varphi\gamma\mathrm{NPV}_g + \Big(\varphi\gamma(1-\varphi) - \gamma + \varphi\Big)\overline{\mathrm{NPV}} \leq 0 \tag{11}$$

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

4 The Costs and Benefits of Career Concerns

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

(i) Whenever the IPO is successful, the value of the firm at IPO is higher when the VC is career concerned than when it is profit motivated.

(ii) Market breakdowns are less likely when the VC is career concerned than when it is profit motivated.

(iii) As long as the expected NPV is negative, total output or "productive efficiency" is higher when the VC is career concerned than when it is profit motivated.

4.1 Career Concerns Prevent 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 career-concerns equilibrium. I find that career concerns make market breakdowns less likely. This follows from the fact that the unskilled career concerned VC over-invests less than the unskilled profit-motivated VC, as summarized in the next lemma.

LEMMA 4. (UNDERINVESTMENT) *Absent market breakdowns, the career-concerned VC backs the firm less frequently than the 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 career concerned.

LEMMA 5. (IPO VALUE IS HIGHER WITH CAREER CONCERNS) *The value of the firm at the time of the IPO is higher when the VC is career concerned than when it is profit motivated:*

$$\mathbb{E}\left[V_\theta \,\middle|\, a=1\right]\Big|_{\mathrm{CC}} > \mathbb{E}\left[V_\theta \,\middle|\, a=1\right]\Big|_{\mathrm{PM}}. \tag{12}$$

The value premium associated with career concerns is the result of the behavior of the unskilled VC. Because the firms that get backing and IPO are backed either by 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 IPO is backed by a positively informed VC, and therefore is a good firm. Hence, firms backed by career-concerned 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. (CAREER CONCERNS PREVENT MARKET BREAKDOWNS) *Market breakdowns are less likely with a career-concerned VC, in the sense that there is a market breakdown with a profit-motivated VC whenever there is a market breakdown with a career-concerned VC, but not the other way around.*

This result underscores an important positive role that career concerns can play: they alleviate the information frictions that prevent firms from being able to raise capital and make positive-NPV investments. Since VCs back the firm relatively infrequently in the career-concerns equilibrium, the firm's expected value at the time of the IPO is high, as Lemma 5 underscores. Thus, in the career-concerns equilibrium, VC-backing has a *certification effect.* This certification effect induces IPO bidders to provide capital, preventing market breakdowns.

4.2 Productive Efficiency

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

First, I give a formal definition of productive efficiency.

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

$$W := \iota\big(V_\theta - I\big). \tag{13}$$

W measures net output because the NPV $V_\theta - I$ is realized only if I is successfully raised in the IPO, or $\iota = 1$.[15]

Now I can compare W in the profit-motivation equilibrium with W in the career-concerns equilibrium.

PROPOSITION 4. (CAREER CONCERNS CAN INCREASE EFFICIENCY) *Productive efficiency is higher in the career-concerns 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 positive side of career concerns: with career concerns, 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. However, if the average NPV of the firm is positive, it decreases productive efficiency. In this case, it is better just to have average NPV firms backed indiscriminately (as in the profit-motivation equilibrium), than to undertake only a selection of better firms (as in the career-concerns 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. (PRODUCTIVE EFFICIENCY: COMPARATIVE STATICS WITH RESPECT TO γ) *The absolute difference between productive efficiency with a career-concerned VC and with a profit-motivated VC is decreasing in the proportion of skilled VCs, i.e.,*

$$\frac{\partial}{\partial \gamma} \Big| \mathbb{E}\left[W_{\text{CC}}\right] - \mathbb{E}\left[W_{\text{PM}}\right] \Big| \leq 0. \tag{14}$$

Proposition 4 says that career concerns help most when the average NPV is negative. I now ask, given the average NPV is negative, when do career concerns help the most? Do they help more when there are a lot of fairly good investment opportunities—high φ, but low V_g—or when there are relatively few very good investment opportunities—low φ, but high V_g?

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

Corollary 4. (Productive Efficiency: Comparative Statics With Respect to φ) *Suppose* $\overline{\text{NPV}} < 0$*. For a given average NPV, the benefits of career concerns for productive efficiency are decreasing in the proportion of good firms, i.e., if* $\overline{\text{NPV}} < 0$*, then*

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

This result says that career concerns help the most in the environment in which VCs operate in practice, i.e., in which most deals involve losing a little bit, but a few deals (the Googles and the Facebooks) involve making a lot.

5 Extensions and Robustness

In this subsection, 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 about the firm's type even if it does not get VC backing.

(ii) I assume the VC sells its equity stake at the time of the IPO, instead of retaining it.

(iii) I add asymmetric information among IPO bidders to generate an IPO discount.

(iv) I consider an alternative specification of the career-concerns component of the VC's preferences to capture a non-linear 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.

5.1 Assets in Place

In the baseline model, I assume that if the firm does not receive backing then its value is zero. This assumption determines the VC's behavior in the career-concerns equilibrium: because both the good firm and the bad firm have value zero 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," i.e., the 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 degree of 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 perfectly from the value of the assets in place regardless of whether the VC backs the firm. I show first that the career-concerned VC's behavior is qualitatively the same as it is in the baseline model. Further, I argue that increasing q attenuates the benefits of career concerns 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, i.e., 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. With probability $1-q$ it is unable to continue at all and the firm 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,

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

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

Lemma 6. (Equilibrium Characterization with a Career-concerned VC and Assets in Place) *Suppose the VC is career concerned. The unskilled VC backs the firm with probability μ^q defined by equation (A.72) in the proof. If*

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

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 career-concerns 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. 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 career-concerns 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. (Assets in Place Interpolate Between Equilibria) *Consider the model with assets in place and a career-concerned VC. If $q = 0$, the equilibrium is* *the career-concerns equilibrium of the baseline model in Proposition 2. If $q = 1$, the equilibrium is the career-concerns 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. I.e., increasing the correlation between the assets in place and the expansion project monotonically interpolates between the career-concerns equilibrium and the benchmark equilibrium.*

This result implies that increasing q attenuates the effect of career concerns on market breakdowns (Proposition 3) and on productive efficiency (Proposition 4).

PROPOSITION 5. (MARKET BREAKDOWNS AND EFFICIENCY WITH ASSETS IN PLACE) *If the firm has assets in place, the results in Section 4 on the benefits of career concerns are attenuated as follows:*

- (IPO VALUE) *The higher is q the lower is the value premium associated with career concerns; i.e., the difference $\mathbb{E}\left[V_\theta \,\middle|\, a = 1\right]\Big|_{\mathrm{CC}} - \mathbb{E}\left[V_\theta \,\middle|\, a = 1\right]\Big|_{\mathrm{PM}}$ is decreasing in q.*
- (MARKET BREAKDOWNS) *The higher is q the less career concerns help in preventing market breakdowns.*
- (PRODUCTIVE EFFICIENCY) *The higher is q the less career concerns affect productive efficiency, i.e., the absolute difference $\left|\mathbb{E}\left[W_{\mathrm{CC}}\right] - \mathbb{E}\left[W_{\mathrm{PM}}\right]\right|$ is decreasing in q.*

5.2 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 career concerns in Section 4 above.

Consider the variation of the model in which the VC exits at the IPO, selling its stake at the market price. Here, the career-concerns 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:

$$\Pi_{\mathrm{PM}} = \begin{cases} \mathbb{E}\left[V_\theta \,\middle|\, a = 1\right] - I & \text{if IPO succeeds,} \\ 0 & \text{otherwise.} \end{cases} \tag{18}$$

Observe that this payoff does not depend on the VC's type, but depends on only 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. (Equilibrium Characterization with a Profit-motivated VC that Sells at IPO) *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.*

Since even the negatively informed profit-motivated VC backs the firm in this equilibrium, the over-investment problem in the profit-motivation equilibrium is especially severe. As a result, the results on the benefits of career concerns in Section 4 are amplified.

Proposition 6. (Benefits of Career Concerns when VC Sells at IPO) *If the VC sells at the IPO, it amplifies the results in Section 4 on the benefits of career concerns 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,*

$$\mathbb{E}\left[V_\theta \,\middle|\, a=1\right]\Big|_{\text{PM, retain}} > \mathbb{E}\left[V_\theta \,\middle|\, a=1\right]\Big|_{\text{PM, exit}}. \tag{19}$$

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

- (Market Breakdowns) *Whenever* $\overline{\text{NPV}} < 0$*, there is no profit-motivation equilibrium in which the VC backs the firm and the IPO is successful. Thus, career concerns help prevent market breakdowns for a larger range of parameters than in the baseline model (Proposition 3).*

- (Productive Efficiency) *Whenever*

$$\overline{\text{NPV}} < \frac{\varphi\gamma \text{NPV}_g}{1-(1-\gamma)\mu^*}, \tag{20}$$

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

5.3 IPO Discount

In the baseline model, I assume that all IPO bidders are uninformed. In this subsection, I extend the model to include informed IPO bidders, following Rock (1986). I show that the results on the benefits of career concerns in Section 4 are amplified whenever there is adverse selection at the time of the IPO.

In the Rock (1986) model, bidders are rationed when the IPO is oversubscribed. Because informed bidders subscribe to the IPO only when the firm is good, uninformed bidders get the whole stake α when the firm is bad but only the rationed stake $(1-\delta)\alpha$ when the firm is good (δ reflects the proportion of the firm that goes to informed bidders when the IPO is oversubscribed). Thus, the uninformed bidders' break-even constraint in equation (5) above is replaced by a version with rationing:

$$\alpha\mathbb{E}\left[\left(1-\mathbb{1}_{\{V_\theta=V_g\}}\delta\right)\left(V_\theta-I\right)\,\middle|\,a=1\right]=0. \tag{21}$$

This expression implies that there is a lower weight on the payoff when the firm is good, V_g-I, relative to the payoff when the firm is bad, V_b-I. As a result, the IPO price is lower, i.e., the shares are sold at a "discount" because of adverse selection. Hence, market breakdowns are more likely. This risk of market breakdowns can make career concerns even more important, since they help to increase the IPO price and prevent market breakdowns (Lemma 5 and Proposition 3). Indeed, the larger is the IPO discount δ, the more likely it is that career concerns enhance efficiency, i.e., Proposition 4 is extended to some positive NPV firms.

Proposition 7. (Career Concerns Can Increase Efficiency More with an IPO Discount) *Suppose that δ is the proportion of the firm that goes to informed bidders at the IPO. Productive efficiency is higher in the career-concerns equilibrium than in the profit-motivation equilibrium whenever*

$$\overline{\mathrm{NPV}}<\frac{(\delta-\gamma)\varphi}{1-\gamma}\mathrm{NPV}_g. \tag{22}$$

5.4 Non-linear Flow-performance Relationship

In the baseline model, I assume that the career-concerns component of the VC's payoff Π_{CC} is linear in the market's belief about the VC's skill. However, empirically there is a non-linear flow-performance relationship in asset management. Chevalier and Ellison (1999) find that it is convex for mutual funds, whereas evidence in Crain (2016) and Kaplan and Scholar (2005) suggests it is concave for venture capital and private equity, respectively. In this subsection, I show that such a concave flow performance relationship amplifies the results in Section 4 on the benefits of career concerns. However, convexity typically induces risk-taking and, as a result, you might think that a convex flow-performance relationship would overturn these results, leading career-concerned VCs to back firms more frequently. I show that the first part of this intuition is right, but the second is not: indeed, a convex flow-performance relationship induces the VC to back firms more frequently, but it does not overturn the qualitative comparison between profit motivation and career concerns.

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

$$\Pi_{\text{CC}} = \Big(\mathbb{P}\left[\text{ skilled } \mid \text{ public information }\right]\Big)^{\kappa} = \Big(\mathbb{P}\left[s \mid a, \iota V_{\theta}\right]\Big)^{\kappa}. \tag{23}$$

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

This different specification of Π_{CC} 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 career-concerns 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. (Equilibrium Characterization with a Career Concerned VC with General Payoff) *Suppose that the VC is career concerned with payoff given by equation (23). If* $\gamma \geq \frac{\varphi^{1/\kappa}}{1-\varphi+\varphi^{1+1/\kappa}}$ *or*

$$\varphi\gamma\text{NPV}_g + \frac{\varphi^{1/\kappa} - \gamma\left(1-\varphi+\varphi^{1+1/\kappa}\right)}{1-\varphi+\varphi^{1+1/\kappa}}\overline{\text{NPV}} > 0 \tag{24}$$

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

$$\mu^{\kappa} = \max\left\{0\,,\ \frac{\gamma\varphi\big(1-\varphi^{1/\kappa}\big) - \gamma + \varphi^{1/\kappa}}{(1-\gamma)\left(1-\varphi+\varphi^{1/\kappa}\right)}\right\}. \tag{25}$$

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

5.5 V_b Positive

In the baseline model, I assume the final value of the bad firm is negative, $V_b < 0$. This reflects a realistic idea: 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 (Subsection 5.2): the only difference from the baseline model is that the negatively-informed profit-motivated VC backs the firm. As I show in Subsection 5.2, this amplifies my results on the benefits of career concerns in Subsection 4 above.

Consider the variation of the model in which $V_b > 0$. Here, the career-concerns equilibrium is unaffected, since career-concerned VCs care about the market's beliefs alone 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 Subsection 5.2, this implies that either no type of VC backs the firm or all do, including even the negatively-informed VC.

LEMMA 9. (EQUILIBRIUM CHARACTERIZATION WITH A PROFIT-MOTIVATED VC WHEN $V_b > 0$) *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 Subsection 5.2, the over-investment problem in the profit-motivation equilibrium is even more severe here than in the baseline model, amplifying the baseline results on the benefits of career concerns. In fact, Proposition 6 holds here.

5.6 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 so doing, 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 Subsection 2.6). 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 career-concerns component of the payoff is unaffected, since it depends on the market beliefs, not the profits. In contrast, the profit-motivation component changes.

If the VC backs the firm it gets

$$\Pi_{\text{PM}} = \begin{cases} (1-\alpha)V_\theta - c & \text{if IPO succeeds,} \\ -c & \text{otherwise.} \end{cases} \tag{26}$$

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

I show that the profit-motivation equilibrium (Proposition 1) and the career-concerns 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 10. (Equilibrium Characterization with Upfront Costs) *Suppose*

$$\frac{\varphi\gamma \text{NPV}_g + (1-\gamma)\overline{\text{NPV}}}{\varphi\gamma V_g + (1-\gamma)\overline{V}}\overline{V} \geq c \geq \frac{\varphi\gamma \text{NPV}_g + (1-\gamma)\overline{\text{NPV}}}{\varphi\gamma V_g + (1-\gamma)\overline{V}} V_b. \tag{27}$$

As long as the IPO succeeds, the profit-motivation equilibrium strategies coincide with those in Proposition 1 and the career-concerns equilibrium strategies coincide with those in Proposition 2.

6 Conclusion

This paper examines the effects of the career concerns 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 career concerns can improve efficiency. VCs can mitigate asymmetric-information frictions in the IPO market, allowing good firms to raise capital due to a a certification effect of VC-backing. In summary, this paper uncovers a new positive side of delegated investors' career concerns that is at work in the primary market.

A Proofs

A.1 Proof of Lemma 1

Whenever the IPO is successful,

$$\alpha = \frac{I}{\mathbb{E}\left[V_\theta \,\middle|\, a = 1\right]}, \tag{A.1}$$

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

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 it Pareto dominates equilibria in which the IPO does not succeed. And, finally, I show that it is the unique equilibrium that survives a refinement akin to the Intuitive Criterion.

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 uniformed VC play $a = 1$, and (iii) the negatively informed VC plays $a = 0$. Thus, the expected value of the firm conditional on $a = 1$ is

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

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

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

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 back the firm and the positively informed VC prefers to back the firm.

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

Uniqueness given IPO success

The VC's best-responses above imply that whenever the IPO is successful, i.e., $0 < \alpha < 1$, 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. $\square$

Pareto dominance if IPO 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 the 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.) $\square$

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 the 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.[16] Now consider an equilibrium in which no type of VC backs the firm. The restriction on beliefs implies bidders believe deviations come from the positively informed VC, since $(1-\alpha)V_g > (1-\alpha)\overline{V} > (1-\alpha)V_b$ whenever $\alpha \in (0, 1)$. Thus, the positively informed VC indeed deviates (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 these equilibria in which no type of VC backs the firm whenever $\overline{\mathrm{NPV}} > 0$. This is because the Intuitive Criterion restricts beliefs such that bidders assign

[16]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: (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 exactly 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.

zero probability to deviations that come from VC types that would be worse off from deviating, no matter the bidders' response. Since $V_b < 0$, this immediately implies 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, the bidders will not provide capital if they believe 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.

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 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:

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

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

$$\mathbb{E}\left[\Pi^u_{\mathrm{CC}}(a=1)\right] = \varphi\left[\frac{\gamma}{\gamma + (1-\gamma)\mu}\right]. \tag{A.4}$$

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

$$\mathbb{E}\left[\Pi^u_{\mathrm{CC}}(a=0)\right] = \frac{(1-\varphi)\gamma}{(1-\varphi)\gamma+(1-\gamma)(1-\mu)}. \tag{A.5}$$

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, $\mu = 1$, (ii) the unskilled VC never backs the firm, $\mu = 0$, and (iii) the unskilled VC backs the firm with probability $\mu \in (0,1)$.

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

$$\mathbb{E}\left[\Pi^u_{\mathrm{CC}}(a=1)\right] \geq \mathbb{E}\left[\Pi^u_{\mathrm{CC}}(a=0)\right], \tag{A.6}$$

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

$$\varphi\gamma \geq 1, \tag{A.7}$$

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

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

$$\mathbb{E}\left[\Pi^u_{\mathrm{CC}}(a=1)\right] \leq \mathbb{E}\left[\Pi^u_{\mathrm{CC}}(a=0)\right], \tag{A.8}$$

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

$$\gamma \geq \frac{\varphi}{1-\varphi+\varphi^2} =: \gamma^*. \tag{A.9}$$

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

$$\mathbb{E}\left[\Pi^u_{\mathrm{CC}}(a=1)\right] = \mathbb{E}\left[\Pi^u_{\mathrm{CC}}(a=0)\right] \tag{A.10}$$

or

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

This reduces to

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

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

$$\mu^* \leq \varphi \leq \frac{1}{2-\varphi}. \tag{A.13}$$

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

$$\varphi\gamma(1-\varphi) - \gamma + \varphi \leq \varphi - \gamma\varphi \tag{A.14}$$

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

$$\mathbb{E}\left[\Pi^s_{\text{CC}}(a=1, \theta=g)\right] = \frac{\gamma}{\gamma + (1-\gamma)\mu^*} \tag{A.15}$$

if it backs the firm and

$$\mathbb{E}\left[\Pi^s_{\text{CC}}(a=0, \theta=g)\right] = \frac{(1-\varphi)\gamma}{(1-\varphi)\gamma + (1-\gamma)(1-\mu^*)} \tag{A.16}$$

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

$$\mathbb{E}\left[\Pi^s_{\text{CC}}(a=1, \theta=g)\right] \geq \mathbb{E}\left[\Pi^s_{\text{CC}}(a=0, \theta=g)\right]. \tag{A.17}$$

This inequality reduces to $\mu^* \leq 1/(2-\varphi)$ which is satisfied by Lemma 11 above.

The payoff of a negatively informed VC is

$$\mathbb{E}\left[\Pi^s_{\text{CC}}(a=0, \theta=b)\right] = \frac{(1-\varphi)\gamma}{(1-\varphi)\gamma + (1-\gamma)(1-\mu^*)} \tag{A.18}$$

if it does not back the firm and

$$\mathbb{E}\left[\Pi^s_{\text{CC}}(a=1, \theta=b)\right] = 0 \tag{A.19}$$

if it does back the firm. The negatively informed VC does not back the firm if

$\mathbb{E}\left[\Pi^s_{\mathrm{CC}}(a=0,\theta=b)\right] \geq \mathbb{E}\left[\Pi^s_{\mathrm{CC}}(a=1,\theta=b)\right]$. This inequality is always satisfied, since 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

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

Thus, the IPO succeeds if

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

or

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

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 re-writes as

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

which is always satisfied.[17]

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

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

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

Equilibrium selection in the career-concerns equilibrium

In Proposition 2, I characterized 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," i.e., 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 firm is revealed with probability δ.[18] I will 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

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

[18] Including assets in place as in Subsection 5.1 provides a micro-foundation for this assumption.

always off the equilibrium path. Thus I no longer have to deal with off-the-equilibrium path beliefs.

I now define a *perverse* equilibrium.

Definition 2. (Perverse Equilibrium) *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, i.e.,*

$$\mathbb{P}\left[s|a=1,V_b\right] \geq \mathbb{P}\left[s|a=1,V_g\right]. \tag{A.25}$$

I restrict attention to non-perverse equilibria, since in perverse equilibria the unskilled VC would make higher profit 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, non-perverse equilibria.

Proposition 9. (All Reasonable Non-perverse Career-concerns Equilibria) *For $\eta \to 0^+$ and $\delta \to 0^+$, 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 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 non-perverse equilibrium in which the skilled negatively informed VC backs the firm and the skilled positively informed VC does not back the firm.[19] I prove that this cannot be the case by contradiction.

Suppose a non-perverse equilibrium in which the skilled negatively informed VC backs the firm and the skilled positively informed VC does not back the firm. Thus 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 $a=0$.

[19]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 career-concerned VC's payoff, we can express these conditions as follows:

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

and

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

Combining these inequalities implies that

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

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

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

implying that if $\iota=0$ the equilibrium must be perverse. Thus, it must be that $\iota=1$. But in this case the inequality above reads

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

or

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

Again, this implies the equilibrium is perverse. This contradicts the hypothesis. Thus, in all reasonable non-perverse equilibria the skilled positively informed VC plays $a=1$ and the skilled negatively informed VC plays $a=0$. □

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 as:

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

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

$$\mathbb{E}\left[\Pi^u_{\mathrm{CC}}(a=1)\right] = \varphi \left[\frac{\gamma}{\gamma + (1-\gamma)\mu}\right]. \tag{A.32}$$

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

$$\mathbb{E}\left[\Pi^u_{\mathrm{CC}}(a=0)\right] = (1-\varphi) \left[\frac{\gamma}{\gamma + (1-\gamma)(1-\mu)}\right]. \tag{A.33}$$

I now consider three possible cases.

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

$$\mathbb{E}\left[\Pi^u_{\mathrm{CC}}(a=1)\right] \geq \mathbb{E}\left[\Pi^u_{\mathrm{CC}}(a=0)\right], \tag{A.34}$$

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 $\gamma \in \left[\frac{1-\varphi}{\varphi}, 1\right]$, where the interval is non-empty if and only if $\varphi \in \left[\frac{1}{2}, 1\right]$.

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

$$\mathbb{E}\left[\Pi^u_{\mathrm{CC}}(a=1)\right] \leq \mathbb{E}\left[\Pi^u_{\mathrm{CC}}(a=0)\right], \tag{A.36}$$

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

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

Thus, $\mu^* = 0$ is an equilibrium if and only if $\gamma \in \left[\frac{\varphi}{1-\varphi}, 1\right]$, where the interval is non-empty if and only if $\varphi \in \left[0, \frac{1}{2}\right]$.

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

$$\mathbb{E}\left[\Pi^u_{\mathrm{CC}}(a=1)\right] = \mathbb{E}\left[\Pi^u_{\mathrm{CC}}(a=0)\right], \tag{A.38}$$

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

$$\mathbb{E}\left[\Pi^{s}_{\mathrm{CC}}(a=1, \theta=g)\right] = \frac{\gamma}{\gamma + (1-\gamma)\hat{\mu}} \tag{A.41}$$

if it backs the firm and

$$\mathbb{E}\left[\Pi^{s}_{\mathrm{CC}}(a=0, \theta=g)\right] = 0 \tag{A.42}$$

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

The payoff of a negatively informed VC is

$$\mathbb{E}\left[\Pi^{s}_{\mathrm{CC}}(a=0, \theta=b)\right] = \frac{\gamma}{\gamma + (1-\gamma)(1-\hat{\mu})} \tag{A.43}$$

if it does not back the firm and

$$\mathbb{E}\left[\Pi^{s}_{\mathrm{CC}}(a=1, \theta=b)\right] = 0 \tag{A.44}$$

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 backs the firm with probability $\hat{\mu}$, where

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

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

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

Consider three cases: (i) $\gamma \in \left[\frac{\varphi}{1-\varphi+\varphi^2}, 1\right]$, (ii) $\gamma \in \left[0, \frac{\varphi}{1-\varphi+\varphi^2}\right]$ and $\varphi \leq 1/2$, and (iii) $\gamma \in \left[0, \frac{\varphi}{1-\varphi+\varphi^2}\right]$ 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 career-concerned VC. That is, there is a market breakdown if

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

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

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

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 career-concerns 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 career-concerned VC backs it in equality (A.20), we find that

$$\mathbb{E}\left[V_\theta \,\middle|\, a=1\right]\Big|_{\text{CC}} - \mathbb{E}\left[V_\theta \,\middle|\, a=1\right]\Big|_{\text{PM}} = 0 \tag{A.51}$$

whenever $\mu^* = 1$. Since

$$\frac{\partial \mathbb{E}\left[V_\theta \,\middle|\, a=1\right]\Big|_{\text{CC}}}{\partial \mu} = -\frac{\varphi(1-\varphi)\gamma(1-\gamma)(V_g - V_b)}{(\varphi\gamma + \mu(1-\gamma))^2} < 0 \tag{A.52}$$

and $\mathbb{E}\left[V_\theta \,\middle|\, a=1\right]\Big|_{\text{PM}}$ does not depend on μ, the difference $\mathbb{E}\left[V_\theta \,\middle|\, a=1\right]\Big|_{\text{CC}} - \mathbb{E}\left[V_\theta \,\middle|\, a=1\right]\Big|_{\text{PM}}$ 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

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

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

$$\tau_{\text{CC}} := \varphi\gamma\text{NPV}_g + (1-\gamma)\mu^*\overline{\text{NPV}} \le 0. \tag{A.54}$$

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

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

$$\begin{aligned} 0 &\ge \tau_{\text{CC}} \\ &= \varphi\gamma\text{NPV}_g + (1-\gamma)\mu^*\overline{\text{NPV}} \\ &> \varphi\gamma\text{NPV}_g + (1-\gamma)\mu^*\overline{\text{NPV}} + \gamma\mu^*\overline{\text{NPV}} \\ &= \tau_{\text{PM}}. \end{aligned}$$

□

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 career concerned (Proposition 1 and Proposition 2). In this case, the expected productive efficiency (as defined in Definition 1) when the VC is profit motivated is

$$\mathbb{E}\left[W_{\text{PM}}\right] = \varphi\gamma\text{NPV}_g + (1-\gamma)\overline{\text{NPV}}; \tag{A.55}$$

and the expected productive efficiency when it is career concerned is

$$\mathbb{E}\left[W_{\mathrm{CC}}\right] = \varphi\gamma \mathrm{NPV}_g + (1-\gamma)\mu^* \overline{\mathrm{NPV}}. \tag{A.56}$$

Productive efficiency is strictly higher when the VC is career concerned if $\mathbb{E}\left[W_{\mathrm{CC}}\right] > \mathbb{E}\left[W_{\mathrm{PM}}\right]$, or, if

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

□

A.12 Proof of Corollary 3

The proof is by direct computation. Define

$$\Delta W := \mathbb{E}\left[W_{\mathrm{CC}}\right] - \mathbb{E}\left[W_{\mathrm{PM}}\right]. \tag{A.58}$$

So, substituting from equations (A.55) and (A.56), we

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

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

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

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

A.13 Proof of Corollary 4

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

$$\Delta W = \begin{cases} -(1-\gamma)\overline{\mathrm{NPV}} & \text{if } \mu^* = 0, \\ -(1-\varphi)(1-\gamma\varphi)\overline{\mathrm{NPV}} & \text{otherwise.} \end{cases} \tag{A.61}$$

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:

$$\frac{\partial \Delta W}{\partial \varphi} = (1-\gamma\varphi)\overline{\text{NPV}} + \gamma(1-\varphi)\overline{\text{NPV}} - (1-\varphi)(1-\gamma\varphi)(V_g - V_b), \tag{A.62}$$

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

A.14 Proof of Lemma 6

The proof of this lemma is analogous to that of Proposition 2 of the characterization of the career-concerns equilibrium. The only substantive difference is that with probably q the type of the VC 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 ($a = 1$), then the market observes V_θ. If the firm does not receive backing from the VC ($a = 0$), 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:

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

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

$$\mathbb{E}\left[\Pi^u_{\text{CC}}(a=1)\right] = \frac{\varphi\gamma}{\gamma + (1-\gamma)\mu}. \tag{A.63}$$

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

$$\mathbb{E}\left[\Pi^u_{\text{CC}}(a=0)\right] = \frac{(1-q)(1-\varphi)\gamma}{(1-\varphi)\gamma + (1-\gamma)(1-\mu)} + \frac{q(1-\varphi)\gamma}{\gamma + (1-\gamma)(1-\mu)}. \tag{A.64}$$

I now consider three possible cases. (i) $\mu^q = 1$, (ii) $\mu^q = 0$, and (iii) $\mu^q \in (0,1)$.

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

$$\mathbb{E}\left[\Pi^u_{\text{CC}}(a=1)\right] \geq \mathbb{E}\left[\Pi^u_{\text{CC}}(a=0)\right], \tag{A.65}$$

when $\mu = 1$. This reduces to

$$\gamma\varphi \geq 1 - q\varphi, \tag{A.66}$$

or

$$\gamma \geq \frac{1 - q\varphi}{\varphi} =: \gamma_1^q. \tag{A.67}$$

So, $\mu^q = 1$ is an equilibrium if $\gamma \in [\gamma_1^q, 1]$. This interval is non-empty if and only if $\gamma_1^q \leq 1$ or 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

$$\mathbb{E}\left[\Pi^u_{\text{CC}}(a = 1)\right] \leq \mathbb{E}\left[\Pi^u_{\text{CC}}(a = 0)\right], \tag{A.68}$$

when $\mu = 0$. This reduces to

$$\frac{\gamma(1 - \varphi + \varphi^2) - \varphi\gamma^2 q(1 - \varphi) - \varphi}{1 - \varphi\gamma} \geq 0. \tag{A.69}$$

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

$$\gamma \geq \frac{1 - \varphi + \varphi^2 + \sqrt{(1 - \varphi + \varphi^2)^2 + 4\varphi^2 q(1 - \varphi)}}{2q\varphi(1 - \varphi)} =: \gamma_0^q. \tag{A.70}$$

(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 non-empty if and only if $\gamma_0^q \leq 1$ or 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, i.e.

$$\mathbb{E}\left[\Pi^u_{\text{CC}}(a = 1)\right] = \mathbb{E}\left[\Pi^u_{\text{CC}}(a = 0)\right], \tag{A.71}$$

or

$$\frac{\varphi\gamma}{\gamma + (1 - \gamma)\mu} = \frac{(1 - q)(1 - \varphi)\gamma}{(1 - \varphi)\gamma + (1 - \gamma)(1 - \mu)} + \frac{(1 - \varphi)q\gamma}{\gamma + (1 - \gamma)(1 - \mu)}. \tag{A.72}$$

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 sum up the unskilled VC's equilibrium mixing probability μ^q is

$$\mu^q = \begin{cases} 0 & \text{if } \gamma \in [\gamma_0^q, 1], \\ 1 & \text{if } \gamma \in [\gamma_1^q, 1], \\ m^q & \text{otherwise.} \end{cases} \tag{A.73}$$

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

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

if it backs the firm and

$$\mathbb{E}\left[\Pi_{\text{CC}}^s(a=0,\theta=g)\right] = \frac{(1-q)(1-\varphi)\gamma}{(1-\varphi)\gamma + (1-\gamma)(1-\mu^q)} \tag{A.75}$$

if it does not back the firm.

The positively informed VC backs the firm if

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

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 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:

$$\mathbb{E}\left[\Pi_{\text{CC}}^s(a=1,\theta=g)\right] \geq \mathbb{E}\left[\Pi_{\text{CC}}^u(a=1)\right] = \mathbb{E}\left[\Pi_{\text{CC}}^u(a=0)\right] \geq \mathbb{E}\left[\Pi_{\text{CC}}^s(a=0,\theta=g)\right] \tag{A.76}$$

by comparing equation (A.64) with equation (A.74).

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

$$\mathbb{E}\left[\Pi_{\text{CC}}^s(a=1,\theta=g)\right] \geq \mathbb{E}\left[\Pi_{\text{CC}}^u(a=1)\right] \geq \mathbb{E}\left[\Pi_{\text{CC}}^u(a=0)\right] \geq \mathbb{E}\left[\Pi_{\text{CC}}^s(a=0,\theta=g)\right]. \tag{A.77}$$

(iii) $\mu^q = 0$. In this case, the unskilled VC never backs the firm. Thus, the skilled positive informed VC is never pooled with the unskilled VC if it backs the firm. Thus, in equilibrium, 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

$$\mathbb{E}\left[\Pi^s_{\text{CC}}(a=0,\theta=b)\right] = \frac{(1-q)(1-\varphi)\gamma}{(1-\varphi)\gamma + (1-\gamma)(1-\mu^q)} + \frac{q\gamma}{\gamma + (1-\gamma)(1-\mu^q)} \tag{A.78}$$

if it does not back the firm and

$$\mathbb{E}\left[\Pi^s_{\text{CC}}(a=1,\theta=b)\right] = 0 \tag{A.79}$$

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

$$\mathbb{E}\left[V_\theta \,|\, a=1\right] = \frac{\varphi\gamma V_g + (1-\gamma)\mu^q \overline{V}}{\varphi\gamma + (1-\gamma)\mu^q}. \tag{A.80}$$

Thus, the IPO succeeds if

$$\frac{\varphi\gamma V_g + (1-\gamma)\mu^q \overline{V}}{\varphi\gamma + (1-\gamma)\mu^q} > I. \tag{A.81}$$

This is the condition in the proposition. □

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.72) that defines μ^q coincides with equation (A.11) that defines μ^* when $q = 0$ and coincides with equation (A.39) that defines $\hat{\mu}$ when $q = 1$.

From equation (A.72), μ^q is the solution of

$$\frac{\varphi\gamma}{\gamma + (1-\gamma)\mu} - \frac{(1-q)(1-\varphi)\gamma}{(1-\varphi)\gamma + (1-\gamma)(1-\mu)} - \frac{q(1-\varphi)\gamma}{\gamma + (1-\gamma)(1-\mu)} = 0. \tag{A.82}$$

Implicitly differentiating with respect to q gives

$$\frac{\partial \mu^q}{\partial q} = \frac{\dfrac{\gamma(1-\varphi)}{(1-\varphi)\gamma + (1-\gamma)(1-\mu)} - \dfrac{\gamma(1-\varphi)}{\gamma + (1-\gamma)(1-\mu)}}{\dfrac{q(1-\gamma)\gamma(1-\varphi)}{(\gamma + (1-\gamma)(1-\mu))^2} + \dfrac{(1-\gamma)\gamma\varphi}{(\gamma + (1-\gamma)\mu)^2} + \dfrac{(1-q)(1-\gamma)\,\gamma(1-\varphi)}{((1-\varphi)\gamma + (1-\gamma)(1-\mu))^2}} \geq 0, \tag{A.83}$$

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

Proof of Proposition 5

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

$$\mathbb{E}\left[V_\theta \,\middle|\, a=1\right]\Big|_{\text{CC}} - \mathbb{E}\left[V_\theta \,\middle|\, a=1\right]\Big|_{\text{PM}} = \frac{(V_g - \overline{\text{NPV}})(1-\gamma)\gamma\varphi(1-\mu^q)}{(\varphi\gamma + 1 - \gamma)(\varphi\gamma + (1-\gamma)\mu^q)}. \tag{A.84}$$

Note that it is decreasing in q:

$$\frac{\partial}{\partial q}\left(\mathbb{E}\left[V_\theta \,\middle|\, a=1\right]\Big|_{\text{CC}} - \mathbb{E}\left[V_\theta \,\middle|\, a=1\right]\Big|_{\text{PM}}\right) = -\frac{(V_g - \overline{\text{NPV}})(1-\gamma)\gamma\varphi\frac{\partial\mu^q}{\partial q}}{(\varphi\gamma + (1-\gamma)\mu^q)^2}, \tag{A.85}$$

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

$$\left|\mathbb{E}\left[W_{\text{CC}}\right] - \mathbb{E}\left[W_{\text{PM}}\right]\right| = \left|(1-\gamma)(1-\mu^q)\overline{\text{NPV}}\right|. \tag{A.86}$$

Note that it is decreasing in q:

$$\frac{\partial\left|\mathbb{E}\left[W_{\text{CC}}\right] - \mathbb{E}\left[W_{\text{PM}}\right]\right|}{\partial q} = -\frac{\partial\mu^q}{\partial q}|\overline{\text{NPV}}|, \tag{A.87}$$

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

A.16 Proof of Lemma 8

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

$$\mathbb{E}\left[V_\theta\right] - I \equiv \overline{\text{NPV}} > 0, \tag{A.88}$$

which holds by the hypothesis in the lemma.

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

A.17 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

$$\mathbb{E}\left[V_\theta \,\middle|\, a=1\right]\Big|_{\text{PM, exit}} = \varphi V_g + (1-\varphi)V_b. \tag{A.89}$$

This is less than the expression for $\mathbb{E}\left[V_\theta \,\middle|\, a=1\right]\Big|_{\text{PM, retention}}$ 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 career-concerns equilibrium. This is because if the IPO is unsuccessful in the career-concerns 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.

Now, if the IPO is successful, the 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 career-concerns equilibrium is given by equation (A.56),

$$\mathbb{E}\left[W_{\text{CC}}\right] = \varphi\gamma \text{NPV}_g + (1-\gamma)\mu^* \overline{\text{NPV}}. \tag{A.90}$$

Thus, career concerns increase productive efficiency whenever $\overline{\text{NPV}} < \mathbb{E}\left[W_{\text{CC}}\right]$ or

$$\overline{\text{NPV}} < \frac{\varphi\gamma \text{NPV}_g}{1-(1-\gamma)\mu^*}, \tag{A.91}$$

which is the equation in the proposition. □

A.18 Proof of Proposition 7

First, I present two lemmata describing the profit-motivation equilibrium (Lemma 12) and the career-concern equilibrium (Lemma 13). Then I prove the proposition, which implies that the larger is the discount δ, the larger is the range of parameters for which career concerns improve productive efficiency.

Lemma 12. *Suppose the VC is profit motivated. If*

$$(1-\delta)\varphi \text{NPV}_g + (1-\varphi)(1-\gamma)\text{NPV}_b > 0, \tag{A.92}$$

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.92) 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. Since it must be 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. From equation (21), this is

$$\mathbb{E}\left[\left(1 - \mathbb{1}_{\{V_\theta = V_g\}}\delta\right)\left(V_\theta - I\right) \,\middle|\, a = 1\right] > 0 \tag{A.93}$$

or

$$\frac{(1-\delta)\varphi}{\varphi + (1-\varphi)(1-\gamma)}(V_g - I) + \frac{(1-\varphi)(1-\gamma)}{\varphi + (1-\varphi)(1-\gamma)}(V_b - I) > 0 \tag{A.94}$$

which is the condition in the lemma above. □

LEMMA 13. *Suppose the VC is career concerned. As long as either $\gamma \geq \varphi/(1-\varphi+\varphi^2)$ or*

$$(1-\delta)\varphi^2\Big(1 + (1-\varphi)\gamma\Big)\mathrm{NPV}_g + (1-\varphi)\Big(\varphi\gamma(1-\varphi) - \gamma + \varphi\Big)\mathrm{NPV}_b > 0, \tag{A.95}$$

then 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.95) 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. From equation (21), the IPO succeeds if

$$\frac{(1-\delta)\varphi\Big(\gamma + (1-\gamma)\mu^*\Big)}{\varphi\gamma + (1-\gamma)\mu^*}(V_g - I) + \frac{(1-\varphi)(1-\gamma)\mu^*}{\varphi\gamma + (1-\gamma)\mu^*}(V_b - I) > 0. \tag{A.96}$$

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

Efficiency. If VCs are profit motivated there is a market breakdown whenever

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

Now observe that the condition in the proposition (equation (22)) is exactly the condition for $\tau_{\mathrm{PM}} < 0$, 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 implies immediately that productive efficiency is weakly higher in the career-concerns 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 career concerns. In particular, if the VC is career concerned there is a market breakdown whenever

$$\tau_{\text{CC}} := (1-\delta)\varphi\Big(\gamma + (1-\gamma)\mu^*\Big)\text{NPV}_g + (1-\varphi)(1-\gamma)\mu^*\text{NPV}_b < 0. \tag{A.98}$$

Now the result follows from the fact that $\tau_{\text{CC}} > \tau_{\text{PM}}$:

$$\tau_{\text{CC}} - \tau_{\text{PM}} = -(1-\delta)\varphi\text{NPV}_g - (1-\varphi)\text{NPV}_b > 0, \tag{A.99}$$

whenever inequality (22) is satisfied. □

Proof of Proposition 8

The proof of this proposition is analogous to that of Proposition 2 of the characterization of the career-concerns equilibrium. The only substantive difference is that the career-concerned VC's payoff is a non-linear function of its beliefs. I will 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, $\mu = 1$, (ii) the unskilled VC never backs the firm, $\mu = 0$, and (iii) the unskilled VC backs the firm with probability $\mu \in (0, 1)$.

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

$$\mathbb{E}\left[\Pi^u_{\text{CC}}(a=1)\right] \geq \mathbb{E}\left[\Pi^u_{\text{CC}}(a=0)\right], \tag{A.100}$$

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 that $\mu^\kappa < 1$.

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

$$\mathbb{E}\left[\Pi^u_{\text{CC}}(a=1)\right] \leq \mathbb{E}\left[\Pi^u_{\text{CC}}(a=0)\right], \tag{A.103}$$

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

$$\mathbb{E}\left[\Pi^{u}_{\mathrm{CC}}(a=1)\right] = \mathbb{E}\left[\Pi^{u}_{\mathrm{CC}}(a=0)\right] \tag{A.106}$$

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

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

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

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

Lemma 14. *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

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

whenver $\kappa > 0$.

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

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

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

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

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

$$\mathbb{E}\left[\Pi^s_{\mathrm{CC}}(a = 1, \theta = g)\right] \geq \mathbb{E}\left[\Pi^s_{\mathrm{CC}}(a = 0, \theta = g)\right], \tag{A.113}$$

or

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

This inequality reduces to $\mu^\kappa < 1/(2 - \varphi)$ which is satisfied by Lemma 14 above.

The negatively informed VC does not back the firm if

$$\mathbb{E}\left[\Pi^s_{\mathrm{CC}}(a = 0, \theta = b)\right] \geq \mathbb{E}\left[\Pi^s_{\mathrm{CC}}(a = 1, \theta = b)\right], \tag{A.115}$$

or

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

This inequality is always satisfied.

Bidders. Following from Lemma 1, the IPO succeeds if

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

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

In case (i), inequality (A.117) re-writes as

$$\varphi\gamma \mathrm{NPV}_g > 0, \tag{A.118}$$

which is always satisfied.[20]

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

$$\varphi\gamma \mathrm{NPV}_g + \frac{\varphi^{1/\kappa} - \gamma\left(1 - \varphi + \varphi^{1+1/\kappa}\right)}{1 - \varphi + \varphi^{1/\kappa}}\, \overline{\mathrm{NPV}} > 0. \tag{A.119}$$

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 14 that $\mu^* < \mu^\kappa$ if and only if $\kappa > 1$—i.e., if and only if the flow-performance relationship is convex—establishes the proposition. □

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

A.19 Proof of Lemma 9

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

$$\mathbb{E}\left[V_\theta \,|\, a = 1\right] = \overline{V}. \tag{A.120}$$

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

$$\overline{V} > I. \tag{A.121}$$

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 $(1-\alpha)\overline{V}$. Since $0 < \alpha < 1$ and $\overline{V} > 0$, the unskilled VC backs the firm. □

A.20 Proof of Lemma 10

Profit-Motivation Equilibrium

Suppose 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 (26).

Bidders. Following Lemma 1, the IPO succeeds if

$$\frac{\varphi\gamma V_g + (1-\gamma)\overline{V}}{\varphi\gamma + 1 - \gamma} > I. \tag{A.122}$$

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

$$\alpha = \frac{\big(\varphi\gamma + 1 - \gamma\big) I}{\varphi\gamma V_g + (1-\gamma)\overline{V}} \tag{A.123}$$

Unskilled VC. I now verify that the unskilled VC prefers to back the firm rather than not to back the firm. From equation (26), the unskilled VC's expected payoff if it backs the firm is

$$\mathbb{E}\left[\Pi^u_{\mathrm{PM}}\right] = (1-\alpha)\overline{V} - c = \frac{\varphi\gamma \mathrm{NPV}_g + (1-\gamma)\overline{\mathrm{NPV}}}{\varphi\gamma V_g + (1-\gamma)\overline{V}}\overline{V} - c, \tag{A.124}$$

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 it will receive $(1-\alpha)V_g - c > (1-\alpha)\overline{V} - c$.

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

$$\mathbb{E}\left[\Pi^u_{\mathrm{PM}}\right] = \frac{\varphi\gamma \mathrm{NPV}_g + (1-\gamma)\overline{\mathrm{NPV}}}{\varphi\gamma V_g + (1-\gamma)\overline{V}} V_b - c. \tag{A.125}$$

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

Career-concerned Equilibrium

Since the payoff of the career-concerned VC does not depend on profits, it is not affected by the addition of the upfront cost c. Thus, its behavior is unchanged. □

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