The Limits of Reputation

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Abstract

Having a reputation for a desirable attribute (such as skill) generally makes a party more attractive as a partner. However, it can also cause problems in a multi-stage relationship because it increases the future demand for a reputable party's services by others. This endogenous increase in their outside option makes it costly for them to continue existing relationships, creating a conflict between maximizing project value and maximizing reputational rents. This not only decreases the effort put into existing partnerships, but also makes partnering with non-reputed parties more attractive. The effect is heightened if non-reputed parties can use the relationship to gain reputation, and are willing to share their expected reputational rents. As a result, there is a feedback loop wherein reputation leads to a loss of potentially profitable relationships, which increases the opportunities for others to become reputable, thereby increasing future competition. This significantly reduces the value of gaining a reputation in the first place. We focus our analysis on relationships between entrepreneurs and venture capitalists, and provide new testable implications.

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1. Introduction

Existing literature points out many positive aspects of reputation, imputing significant value to its creation and preservation.[1] This value can arise, for example, from higher demand for a reputable party's services now or in the future. In this paper we identify a paradox associated with this channel: when future demand for their services is an important component of rents for reputable parties, an increase in this demand can make them undesirable as partners, and therefore unable to capture these rents. In the context of multi-stage relationships, the better outside opportunities available to reputable partners in later stages create a conflict because the maximization of reputational rents can be at odds with the maximization of project value. This leads to a lower ex ante value of continuation options, which decreases the attractiveness of such relationships and the amount of effort the parties are willing to invest in them. It also makes some parties choose to enter relationships with less reputable partners who desire to gain reputation through such relationships and are willing to share their expected reputational rents toward that end. This not only results in a social loss, but also in a feedback loop wherein reputation leads to a loss of potentially profitable relationships, which also increases the opportunity for others to become reputable, thereby increasing future competition. This significantly limits the value of gaining a reputation in the first place.

We focus our analysis on relationships between entrepreneurs and venture capitalists (VCs) because of the multi-stage nature of start-up funding and the large literature that documents the positive aspects of VC reputation. Indeed, many papers support the idea that more reputable VCs are associated with better outcomes for start-ups, both because they more often fund higher quality firms (screening), and because they directly add value and improve the firms' outcomes (influence) (see Chemmanur et al. (2011), Krishnan et al. (2011), Nahata (2008), and Sørensen (2007)).[2] Hsu (2004) shows that entrepreneurs are willing to accept substantially lower valuations

[1]See, e.g., Kreps and Wilson (1982), Milgrom and Roberts (1982), Fudenberg and Levine (1992), and Holmström (1999).

[2]There is a large complementary literature showing that VCs add value to startups in multiple ways, such as certification, monitoring and advising (see, e.g., Hellmann and Puri (2000, 2002), Lerner (1995), Megginson and Weiss (1991), and Lee and Wahal (2004)).

(a 10-14% discount on average) when partnering with a reputable VC. In addition, the literature views reputation as a valuable asset for a VC. For example, Gompers and Lerner (1999) and Kaplan and Schoar (2005) show that more reputable VCs have significant advantages in fundraising. In addition, Hochberg et al. (2007) show that better connected VCs have better performance, while Lerner (1994) shows that more experienced VCs may have advantages in getting access to syndicated deals involving promising firms. [3] While this literature focuses on the reasons why VC reputation is valuable to both entrepreneurs and VCs, our analysis shows that there are also downsides to reputation that can lead entrepreneurs to prefer relationships with less reputable VCs in some circumstances, and provides testable empirical implications for future empirical work.

We first analyze a static stage game, which is then embedded in a dynamic setting. In the static game, an entrepreneur has access to a two period project whose value depends on both the skill level of the VC who funds it and the effort choice of the entrepreneur. VCs can be skilled or unskilled, and the entrepreneur potentially has access to both reputable VCs (who are known to be skilled) and non-reputable VCs (who are *potentially* skilled). Both kinds offer staged financing contracts to the entrepreneur.

Once a VC is chosen and the contract signed, the VC provides an initial investment, and the entrepreneur makes an effort decision. However, the parties are expected to renegotiate the terms of the contract in the second period when they face choice between an immediate sale of the project or an additional investment to attempt a riskier “late exit” (such as an IPO). This renegotiation stage introduces the possibility of hold up by the VC since the entrepreneur is unable to fund the additional investment on his own for a late exit. At both negotiation stages, a reputable VC has the outside option of returning to the market to seek a new match and thereby capture the value of its reputation.

In this setting, we show that, despite the fact that VC skill is unambiguously valuable for increasing the project’s exit value, choosing a reputable VC has a downside and the entrepreneur will sometimes prefer contracting with a non-reputable VC. These results arise from the interaction between the reputable VC’s high outside option (the value of its reputation) and the non-reputable

[3] Furthermore, Gompers (1996) finds that younger VCs appear to value reputation enough that they attempt to gain it quickly by taking their portfolio companies public as early as possible (“grandstanding”).

VC's desire to gain reputation. From an ex ante perspective, a reputable VC knows it will have a high value from returning to the market to be potentially matched with a better project at the same time it is considering whether to continue funding its existing project. Thus, anytime it chooses to continue the existing project and forego the opportunity of finding a new project it pays an implicit cost that is increasing in the value of its reputation. To mitigate this cost, continuation will be chosen less often, which reduces expected project value. The combination of these factors causes the reputable VC to assign lower value to the continuation, or late exit, option.

On the other hand, a non-reputable VC wants to gain reputation for skill, which can only be accomplished by carrying a project through to a successful late exit. Thus, it values the late exit option more highly, and may be willing to "bribe" the entrepreneur (i.e., share its expected reputational rents) ex ante to induce a relationship in the hope of being discovered as skilled. In addition, at the renegotiation stage the reputable VC will drive a harder bargain because it is implicitly less valuable to him to continue the relationship, which exacerbates the hold up problem and leads to reduced entrepreneurial effort. The non-reputable VC, meanwhile, places much greater value on continuing the project and therefore is willing to leave more of the exected surplus to the entrepreneur, alleviating the hold up problem and boosting entrepreneurial effort. In our static analysis, we show that the greater is the value of reputation that can be enjoyed when a reputable VC returns to the market, the more important are these forces and thus the more likely it is that the entrepreneur will choose a non-reputable partner.

We next embed this stage game in a dynamic, discrete-time model in which both the value of reputation and the number of reputable VCs is derived endogenously. In the model there is a mass of both reputable and non-reputable VCs, as well as a mass of entrepreneurial projects that can be one of two types: low potential or high potential. While all projects are valuable and benefit from having a higher skill investor, low potential projects are intrinsically of lower quality and thus benefit less from skill. There is a steady arrival of new projects (a unit mass of projects arrives every period, of which a fixed proportion are high potential), and these are matched with VCs available to fund new projects that period. We assume that a VC can fund only one project at a time. There is always a large mass of non-reputable VCs available, and each entering project is matched with at least two of them.

Matching with reputable VCs occurs as follows: available reputable VCs are first randomly matched one-to-one with high potential projects (i.e., no two reputable VCs are ever matched to the same project); if there are more reputable VCs than high-potential projects, reputable VCs are then randomly matched one-to-one with low potential projects, until one or the other mass is exhausted.[4] Thus, a reputable VC that is currently involved with a low potential project has an incentive to prematurely terminate this relationship because it can potentially enter into a new relationship with a high potential project.

Once matched, negotiations between VCs and entrepreneurs conform to the stage game described above. If at the interim date of the project the firm fails to create a viable product or the VC and entrepreneur fail to agree on financing for a late exit, the VC re-enters the market and is randomly matched to a new project, which can be either high or low potential. Otherwise the VC re-enters the market after the late exit attempt is realized. In both cases, the VC "dies" before reaching the market with some probability. We assume that all model parameters are constant, and numerically simulate steady-state equilibria in which we endogenously characterize the mass of reputable VCs, the bargaining outcomes across all firms, and the value of reputation (defined in our model as the present value for a reputable VC of reaching the market to be matched to a new project, taking into account the value of all expected future relationships). This steady-state value represents the VC's outside option at both the initial contracting stage and the renegotiation stage.

In equilibrium, since VC skill is more valuable for high potential firms, reputable VCs always end up funding any high potential project to which they are matched despite competition from non-reputable VCs. However, when a reputable VC is matched to a low potential project the competition from non-reputable VCs can be harder to overcome if the value of reputation is (endogenously) high. In particular, we characterize three types of equilibria: (1) equilibria in which reputable VCs do deals with all entrepreneurs to which they are matched (both high and low potential), (2) equilibria in which reputable VCs do all deals with high potential projects but only some proportion of the

[4]This matching rule is meant to tractably capture the idea that reputable VCs will naturally have preferred access to better projects while simplifying the bargaining game to leave them with reasonable bargaining power vis a vis the entrepreneur (thus the assumption that no two reputable VCs are ever matched to the same firm).

low potential projects to which they are matched, and (3) equilibria in which reputable VCs do not do any deals with low potential projects (and thus sit on the sidelines for at least one period when matched to a low potential project).

In our simulations, we first consider how changes in the proportion of high potential projects entering each period affect the steady-state equilibrium. Intuitively, when the proportion of high potential projects is low, the value of reputation should naturally be relatively low since there is only a small chance of a reputable VC being matched to such a project when entering the market. This means that the downsides of dealing with a reputable VC are not very significant (the VC does not pay a high implicit cost in case of continuation, hold up is less severe, and non-reputable VCs are not as motivated to develop reputation), so reputable VCs are able to do deals with both high and low potential projects, i.e., the equilibrium is of type 1. This also implies that the total steady-state pool of reputable VCs is fairly low, since non-reputable VCs can only do deals (and potentially have their skill discovered) when matched with projects that do not have access to a reputable VC, which is less likely in this type of equilibrium.

As the proportion of high potential projects rises, the value of reputation increases. At some point this precipitates a switch to an equilibrium of type 2: the increasing value of reputation makes the downsides of reputation more prominent, and causes some entrepreneurs to start doing deals with non-reputable VCs even when they have access to a reputable VC. Furthermore, the increase in the value of reputation makes it more attractive for non-reputable VCs to attempt to become reputable, which makes them bargain harder ex ante to entice even more low-potential deals away from the reputable VCs. This erodes some of the value the reputable VCs realize from the increase in the quality of the project pool, since more of them are rejected by low potential firms. There is also an amplification effect: as the transition to type 2 equilibria takes place the steady-state mass of reputable VCs rises as non-reputable VCs get the opportunity to do more deals and have their skill discovered. This further limits the increase in the value of reputation. Thus, in the parameter range where the equilibrium is of type 2, we find that the value of reputation endogenously remains flat even as the proportion of high potential projects rises.

Eventually, the equilibrium transitions to type 3. At this point, reputable VCs can no longer successfully fund any low potential projects since the downsides are too large. Once this parameter region is reached, the mass of reputable VCs declines as the proportion of high potential projects rises. This is because the relative scarcity of low potential projects reduces the opportunity of non-reputable VCs to get deals and potentially be discovered as skilled. However, the value of reputation does start going up again, as the increased probability of being matched to a high potential project is now the main force affecting the reputable VCs.

The endogenous value of reputation always weakly increases as the proportion of high potential projects rises, but its rate of increase is attenuated by the forces described above. This is representative of the overall result that the value of reputation in our model is substantially limited due to the downsides of reputation, and this effect is magnified as the outside option of a reputable VC increases and it faces more effective competition from non-reputable VCs. Indeed, we verify this effect quantitatively by comparing the value of reputation in our model to its value in a modified model that shuts down competition from non-reputable VCs (and gives reputable VCs full bargaining power vis a vis entrepreneurs). We find that the modified model has reputation values ranging from two to seven times higher in the parameter ranges we investigate. Thus, when the key features of our model (multi-stage funding contracts and competition from non-reputable VCs) are present in particular markets or at particular times, our analysis predicts that those situations should exhibit relatively low reputation values and relatively high proportions of reputable VCs forced to sit on the sidelines.

Our simulations provide a number of additional comparative statics and related empirical implications. In particular, we characterize how equilibrium outcomes change as the quality of low potential projects improves, i.e., as they become more like high potential projects. When low potential projects have particularly low quality, the equilibrium tends to be of type 3 because low potential projects gain little from VC skill, and thus prefer to accept offers from non-reputable VCs who would like to gain reputation. However, as the quality of low potential projects rises and it becomes more important to get access to VC skill, the equilibrium type first changes over to type 2 and then to type 1. Thus, we predict more sitting on the sidelines by reputable VCs when there is a large gap between low and high potential projects. Changes in the value of reputation with respect to this parameter are more subtle: at low quality levels when the equilibrium is of type 3, the value of reputation actually falls when the quality of low potential projects improves. This is because these entrepreneurs work harder because of greater expected project value and make it more likely that their non-reputable VCs are discovered to have skill, which increases the mass of reputable VCs that compete for the pool of high potential firms. However, once the equilibrium switches over to type 1 at higher levels of project quality, the value of reputation increases with quality as these relationships become more valuable to reputable VCs who are now doing more of these deals.

We also study the social welfare implications of our model. Since VC skill is instrumental in creating project value, there can be significant welfare effects if that skill is underutilized in the economy, e.g., when reputable VCs are less likely to get deals from low potential firms. Furthermore, VCs looking to capture surplus by gaining reputation may devote excess resources (and encourage excessive effort by entrepreneurs) in this endeavor. To study this, we compare welfare in our model, measured as average realized net present value per project, to that in an alternative model in which any entrepreneur that is matched to a reputable VC loses access to non-reputable VCs. This modified model is similar to the modified model used above to explore the potential value of reputation, but gives the ex ante bargaining power to the entrepreneur so that the value of VC reputation is lower and there is less inefficient reputation-seeking by the non-reputed VCs. The modified model thus maximizes the use of available (known) skill while minimizing reputation-related rent seeking. There is, of course, a countervailing force of potentially fewer VCs with reputation for skill (as fewer non-reputable VCs are funding projects), which could reduce welfare. However, in the parameter ranges we study, we find that welfare is always higher in the modified model, and exceeds welfare in the main model by up to 5%. We also find that the efficiency gap is highest at intermediate levels of both the proportion of high potential projects and the quality of low potential projects (roughly corresponding to the parameter spaces where there is the greatest number of reputable VCs sitting on the sidelines in our main model).

1.1. Literature Review

A number of other papers have pointed out downsides of reputation, but in very different contexts. Ely and Välimäki (2003), like us, show that reputation can undermine commitment power and result in a loss of potential relationships. However, their focus is different as they are concerned with how good agents can gain reputation through signaling and how the desire to maintain that reputation can result in bad decisions. Papers like Scharfstein and Stein (1990), and Zwiebel (1995), show that concerns for maintaining reputation in the labor market can lead to herd behavior by agents, which while individually rational is socially undesirable.[5] We digress from such concerns by assuming that once a VC's skill type is revealed it is known perfectly (and it always acts consistently with its type), and show in this context that reputation can still distort outcomes because having a reputation for skill increases the future demand for such a VC, making it harder for it to credibly commit to long term relationships.

Piacentino (2016) develops a model of career concerned VCs, who seek to maintain their perceived reputation as skilled screeners of projects. Like us, she shows that these career concerns lead to inefficient investment decisions, but in her case it is because unskilled VCs are overly cautious in providing capital up front, not because of better outside options at a continuation stage as in our setting. She also shows that these individually inefficient decisions actually lead to better aggregate outcomes since most investments end up being done by skilled VCs, while in our setting there is an overall social welfare loss due to reputable VCs' attempt to maximize their reputational rents and the resulting loss of potential relationships. A related literature on career concerned institutional investors shows that their attempts to maintain reputation lead to significant inefficiencies in secondary market trading (see, e.g., Dow and Gorton (1997), Dasgupta and Prat (2006, 2008), and Guerrieri and Kondor (2012).)

In the model of Malenko and Malenko (2015) a private equity fund's reputation for not acting opportunistically ex post with creditors can increase the surplus it creates in leveraged buyouts. They show that this reputation mechanism still operates when funds can also have a reputation for skill, as in our setting. In the context of private equity "club" buyouts wherein multiple funds bid as a group, they show that when club members can borrow reputation from each other there is a lower incentive to acquire or maintain individual reputation. In our model, we instead focus on how dealing with a reputed VC reduces the *entrepreneur's* effort level in multi-period deals because of the VC's conflicting desire to maximize reputational rents, which in turn reduces the value of

[5] The intuition in these papers supports Keynes' observation that human behavior seems consistent with a belief "that it is better to fail conventionally than to succeed unconventionally".

reputation to the VC and the ultimate incentive to acquire it.

Hörner (2002) shows that competition among producers of products with uncertain quality increases the effort necessary to maintain reputation and thus reduces the value of acquiring reputation. The threat that customers will defect to a competitor disciplines good firms into choosing high effort, thus making dealing with reputed firms valuable. However, similar to our paper but for a different reason, this can force good firms out of the market as reputation is less valuable because of the costly effort to maintain it. In our paper, on the other hand, the value of reputation is being reduced because of competition from the non-reputed VCs who wish to get reputation for being skilled and are prepared to offer a premium to do so.

Our paper also has similarities with the large literature starting with Sharpe (1990) and Rajan (1992) concerning holdup problems between borrowers and lenders. Both deal with multi-period relationships and in both the borrower is tied to a financier because the financier has private information which makes it costly for the client to switch. This creates an environment where the borrower can be exploited by the financier ex-post. Like in our paper, this hold up problem occurs when a client would like to switch from his financier but cannot without incurring a significant cost. However, in our case this problem is exacerbated the more valuable is reputation because the financier faces conflicting priorities and bargains harder because of his desire to maximize reputational rents. The effect of competition is also important in both settings. In Rajan (1992) a competitor decreases the rents that can be expropriated through holdup by providing an outside option to the client at the refinancing stage, while in our paper competition reduces the rents the financier can extract ex ante since profitable projects can rationally choose an inferior financier even when skilled financiers are available. This both constrains the value of reputation and hurts social welfare as the project's expected value is reduced.

2. The Model: Basic Framework

We start with a description of the basic model of two-stage contracting between a venture capitalist and an entrepreneur. We proceed to solve for the implications of the model with an exogenous value of reputation. Finally, we embed the two-stage contracting model in an infinite-horizon discrete time model of many entrepreneurs and VCs to endogenously derive the value of reputation. In all cases, future payoffs one period ahead are valued using a discount factor β.

The contracting model is based on the holdup model of Khanna and Mathews (2016). Consider a startup firm owned by a wealth-constrained entrepreneur (E) that needs financing over two stages. An initial investment of I_1 is needed at time 0 to perform research and development for a new product. Conditional on development of a viable product, the owners of the firm can choose a safe "early exit" at time 1, or can take a risky bet on a "late exit" strategy (or continuation option) that pays off at time 2.[6] Attempting a late exit requires an additional investment of I_2 at time 1. We assume any capital above I_1 at time 0 would be wasted by the entrepreneur, so stage financing is strictly optimal.

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

At time 1, if the product turns out to be non-viable the initial investment of I_1 is recovered via liquidation, but there is no additional value in the firm. If the product turns out to be viable, then the firm is worth $\pi_1 > I_1$ in an early exit at time 1. If, instead, the firm remains independent and raises an additional investment of I_2 from its current VC, then firm value, realized at time 2, will be either π_2, where $\pi_2 > \pi_1$, π_3, where $\pi_3 > \pi_2$, or zero (i.e., choosing to pursue the risky late exit option results in either greater success or complete failure).[7]

The ability to successfully exit late and realize π_2 or π_3 at time 2 depends on the final state of nature and the type of the VC. The state of nature is $\Theta \in \{G, B\}$, and the random variable s, which is continuously distributed over $[0, 1]$, gives the probability that the state is good. The good state of nature represents an outcome where the firm and its product are of sufficiently high quality

[6]The early exit opportunity could represent, for example, an early M&A exit where a young firm with a nascent product sells out to an existing firm in a related market, whereas the late exit strategy could represent an attempt to develop the firm's product and market more fully to achieve a more profitable initial public offering (IPO) or late M&A exit. The structure and timing of payoffs is all that matters for the results.

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

to complete a successful late exit. If the state of nature is bad, the late exit attempt yields zero. A publicly observable but non-verifiable signal of s is realized at time 1 (we use s to denote both the random variable and the signal). The VC can be one of two types: skilled and unskilled. A skilled VC adds value to the firm and produces a late exit payoff of π_3 if the state of nature is good, while an unskilled VC produces a late exit payoff of π_2 in that state. If the VC is known to be skilled, it is considered a reputable VC. If the VC's skill is unknown, it is considered a non-reputable VC. All non-reputable VCs have an ex ante probability $g \in (0, 1)$ of being skilled and do not know their type upon entering the model. The only way a VC's type can become known (to any agent) is for its investment to have a successful late exit that produces a payoff of either π_2 or π_3. Thus, for simplicity, either a VC's type is know perfectly by all players, or it is completely unknown to all players.

After product viability and the signal s are observed at time 1, E and the VC bargain over the provision of I_2 for a late exit attempt. The bargaining game is assumed to be generalized Nash bargaining with bargaining power of λ for E. Since the signal s is non-verifiable, ex ante contracts cannot be written based on its realization. Thus, the split of any continuation surplus at time 1 in the event of a late exit attempt is entirely subject to the bilateral time 1 bargaining game. For the time 0 bargaining game, we assume that E can always seek offers from at least two non-reputable VCs. It is also matched to one reputable VC, who makes a take-it-or-leave-it offer to the VC. This is to reflect the idea that a reputable VC should be able to extract some value from the relationship, while a non-reputable VC is more easily replaceable and should not. We also assume that any VC "matched" to this firm (i.e., in a position to make an offer to the firm at time 0) cannot approach another firm for a potential investment until time 1.

Figure 1 illustrates the timeline of the contracting game. Branches with dashed lines indicate random events chosen by nature, while those with solid lines are decisions by players in the game. Bold italics indicate final firm payoffs in different outcomes. To summarize, first an initial investment of I_1 is made at time 0. Next, E chooses his effort level e, and then nature determines whether the product is viable. If not viable, liquidation occurs at time 1. If viable, at time 1 the signal s is observed and a late or early exit is chosen. If a late exit is chosen, I_2 must be invested at that time. Following an investment of I_2, the late exit is successful with probability s at time 2, and the final payoff is determined based on the type of the VC.

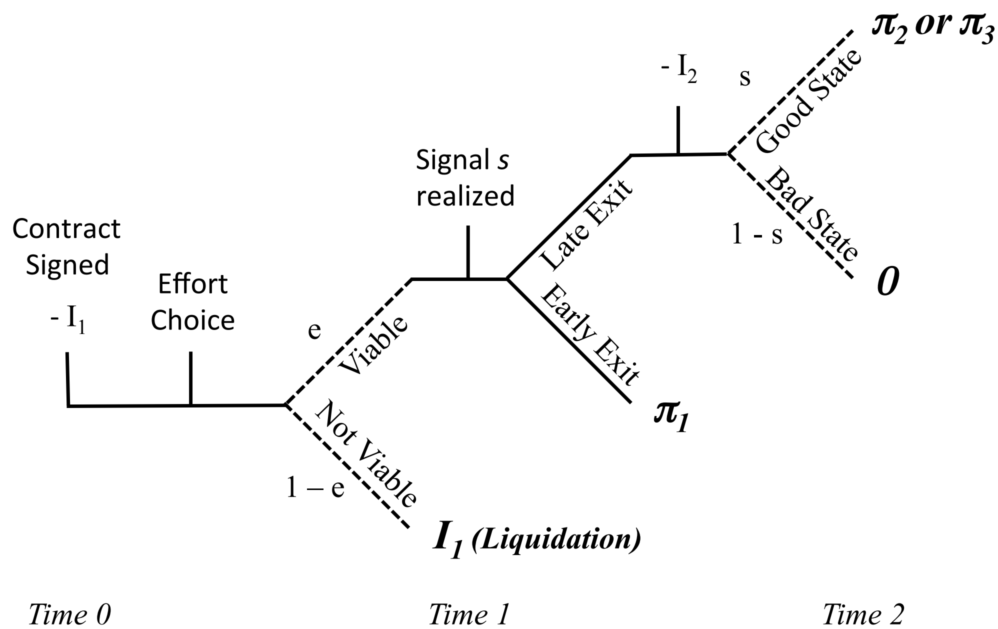

Figure 1
Timeline of the contracting model
The figure illustrates the timeline of the base contracting model. First E receives offers and agrees to the contract, and an initial investment of I_1 is made at time 0. Next, the entrepreneur chooses his effort level e, and then nature determines whether the product is viable. If not viable, liquidation occurs at time 1. If viable, at time 1 the signal s is observed and a late or early exit is chosen. If a late exit is chosen, I_2 must be invested at that time. Following an investment of I_2, the late exit is successful with probability s at time 2, and the final payoff is determined based on the type of the VC.

3. Solution to the Contracting Model

In this section we solve the contracting model to find the optimal contract and characterize its implications. Let V^R be the expected value to a reputable VC of entering the market and searching for a partner. To maintain consistency between the static and dynamic models, we assume the VC has a non-zero probability d of "dying" before reaching the market. A VC who "dies" can no longer participate in the market. For purposes of the static model, we assume that at time 0 the reputable VC that is matched to the firm has already reached the market. A non-reputable VC, since it has no bargaining power, has a value of 0 upon entering the market (this will be verified later). Any VC that was matched to the firm at time zero but does not sign a contract can attempt to re-enter the market and search for a new partner at time 1. A VC who signs a contract with E can also attempt to re-enter the market at time 1 if the project is liquidated or sold in an early exit at that time. Otherwise it cannot re-enter the market and search for a new project until the project is completed at time 2.

One thing we want to focus on is the interaction of the hold-up problem with reputation. Thus, we focus on situations where hold-up is relevant; i.e., those situations where the optimal contract results in less than optimal effort from E. In addition, we place two restrictions on contracts: (i) they must respect limited liability for the VC (no required payments from the VC beyond the initial investment), and (ii) the VC's payoff must be non-decreasing with respect to the value of the firm (a feature common to real life VC contracts).

In the spirit of backward induction, consider the time 1 negotiation assuming a viable product has been created. If staying with the existing entrepreneur for a second period and attempting a late exit is jointly optimal, the parties will negotiate over the VC's stake in the ultimate firm value for a cash infusion of I_2. In this negotiation, the default option is for the firm to be sold for π_1 immediately. Assume that the original (time 0) contract called for the VC to receive a proportion α_1 of the payoff π_1 in this situation. In this case, a reputable VC has a walk-away payoff of $\alpha_1\pi_1 + V^R(1-d)$ while a non-reputable VC has a walkaway payoff of only $\alpha_1\pi_1$. In either case, the entrepreneur has a walkaway payoff of $(1-\alpha_1)\pi_1$. It is jointly optimal to attempt a late exit if it results in higher total continuation surplus than an early exit. With a reputable VC, this is true if

$$\beta s\pi_3 + \beta V^R(1-d) - I_2 \geq \pi_1 + V^R(1-d), \tag{1}$$

while with a non-reputable VC this is true if

$$\beta s\overline{\pi} + \beta sgV^R(1-d) - I_2 \geq \pi_1, \tag{2}$$

where $\overline{\pi} \equiv (g\pi_3 + (1-g)\pi_2)$. In the latter case, the value of entering the market as a reputable VC is enjoyed only if the continuation investment pays off (with probability s) *and* the VC turns out to be skilled (with probability g). Further, if the project is discontinued at time 1, the non-reputable VC's type is not discovered (without observing the final payoff, there is no possibility of an update), so this VC will have to re-enter the market as a non-reputable VC with an expected payoff of 0.

Note that we assume throughout that a VC which has been found to be unskilled is unable to continue to participate in the market.

We define $\underline{s}^i$, $i \in \{N, R\}$, as the minimum s that makes the corresponding equation above hold with equality. In other words,

$$\underline{s}^R \equiv \frac{I_2 + \pi_1 + (1-\beta)V^R(1-d)}{\beta\pi_3} \tag{3}$$

$$\underline{s}^N \equiv \frac{I_2 + \pi_1}{\beta[\overline{\pi} + gV^R(1-d)]}. \tag{4}$$

Thus, the parties will choose to sell the firm now for π_1 if s is below the corresponding $\underline{s}^i$, and will negotiate the provision of I_2 for continuation otherwise. In the renegotiation, E has bargaining power λ, and so will get a continuation payoff equal to her walkaway plus a λ proportion of the increase in surplus if the project is continued. With a reputable VC, this equals

$$\Gamma^R(s) \equiv (1-\alpha_1)\pi_1 + \lambda[\beta s\pi_3 + \beta V^R(1-d) - I_2 - \pi_1 - V^R(1-d)], \tag{5}$$

where the functional notation is meant to remind the reader that this continuation payoff is conditioned on the realized signal s, while with a non-reputable VC it equals

$$\Gamma^N(s) \equiv (1-\alpha_1)\pi_1 + \lambda[\beta s\overline{\pi} + \beta sgV^R(1-d) - I_2 - \pi_1]. \tag{6}$$

The VC's continuation payoff is calculated similarly, so that a reputable VC gets

$$\Phi^R(s) \equiv \alpha_1\pi_1 + V^R(1-d) + (1-\lambda)[\beta s\pi_3 + \beta V^R(1-d) - I_2 - \pi_1 - V^R(1-d)], \tag{7}$$

while a non-reputable VC gets

$$\Phi^N(s) \equiv \alpha_1\pi_1 + (1-\lambda)[\beta s\overline{\pi} + \beta sgV^R(1-d) - I_2 - \pi_1]. \tag{8}$$

Given this renegotiation outcome, we can back up to derive E's effort choice. Assume for now that in the event of a non-viable product, E receives a proportion $(1-\alpha_{I_1})$ of the recovery I_1. His objective function is then

$$\max_e e(\beta Pr[s < \underline{s}^i](1-\alpha_1)\pi_1 + \beta Pr[s \geq \underline{s}^i]E[\Gamma^i | s \geq \underline{s}^i]) + (1-e)(1-\alpha_{I_1})I_1 - c(e), \tag{9}$$

which has first-order condition

$$c'(e) = \beta Pr[s < \underline{s}^i](1-\alpha_1)\pi_1 + \beta Pr[s \geq \underline{s}^i]E[\Gamma^i | s \geq \underline{s}^i] - (1-\alpha_{I_1})I_1. \tag{10}$$

As noted above, we will focus on parameter spaces where effort induced by the optimal contract is less than first best. As a result, the time 0 contracting problem comes down to choosing a contract that maximizes E's effort. The resulting surplus can then be split by the parties with a monetary transfer from the VC to E, which we label τ.

As is immediate from the FOC given the convexity of $c(e)$, effort will be maximized if α_{I_1} is set equal to 1 and α_1 is set equal to zero. However, this would imply that the VC's payoff is lower when the firm is sold for π_1. Thus, the minimum level of α_1 given our restriction to non-decreasing contracts is determined by the relationship $\alpha_1\pi_1 \geq \alpha_{I_1}I_1 \implies \alpha_1 \geq \frac{\alpha_{I_1}I_1}{\pi_1}$. This will hold with equality at the optimum. Plugging this into the FOC yields

$$c'(e) = \beta Pr[s < \underline{s}^i](1-\frac{\alpha_{I_1}I_1}{\pi_1})\pi_1 + \beta Pr[s \geq \underline{s}^i]E[\Gamma^i | s \geq \underline{s}^i] - (1-\alpha_{I_1})I_1. \tag{11}$$

Taking the derivative of the RHS with respect to α_{I_1} yields $I_1 - \beta Pr[s < \underline{s}^i]I_1 > 0$, so the optimal contract sets $\alpha_{I_1} = 1$ and $\alpha_1 = \frac{I_1}{\pi_1}$. In words, this is a debt contract with face value I_1. Let the optimal effort that solves the above FOC with this contract be e^i for $i \in \{N, R\}$, defined by

$$c'(e^i) = \beta Pr[s < \underline{s}^i](\pi_1 - I_1) + \beta Pr[s \geq \underline{s}^i]E[\Gamma^i | s \geq \underline{s}^i]. \tag{12}$$

Since this contract is optimal for both reputable and non-reputable VCs, all relationships will be funded with such a debt contract. What remains to fully solve the contracting problem is the determination of the up-front transfer, τ. First consider the case where the entrepreneur contracts with a non-reputable VC. Since we have assumed that a given entrepreneur can seek offers from at least two non-reputable VCs, the optimal τ, which we label τ^N, should be such that the VC has an expected payoff of zero. This transfer will solve

$$\tau^N = -I_1 + \beta(1-e^N)I_1 + e^N\beta\left(Pr[s < \underline{s}^N]I_1 + Pr[s \geq \underline{s}^N]E[\Phi^N | s \geq \underline{s}^N]\right). \tag{13}$$

When the entrepreneur contracts with a reputable VC, the VC makes a take-it-or-leave-it offer. However, since E has the option to contract with a non-reputable VC with a transfer τ^N, if the reputable VC wants to make a deal with E its offer must make E indifferent to that option. As a result, the required transfer from the reputable VC, labeled τ^R, is determined by the indifference condition

$$\tau^N + e^N(\beta Pr[s < \underline{s}^N](\pi_1 - I_1) + \beta Pr[s \geq \underline{s}^N]E[\Gamma^N|s \geq \underline{s}^N]) - c(e^N)$$
$$=$$
$$\tau^R + e^R(\beta Pr[s < \underline{s}^R](\pi_1 - I_1) + \beta Pr[s \geq \underline{s}^R]E[\Gamma^R|s \geq \underline{s}^R]) - c(e^R) \tag{14}$$

This discussion is summarized in the following result.

Proposition 1 *The contracting model is solved as follows.*

(a) If the reputable VC is willing, it offers a transfer of τ^R and invests I_1 at time 0 in the firm in return for a debt contract with face value I_1. At time 1, if $s \geq \underline{s}^R$, the VC will invest an additional amount I_2 in return for a continuation contract that gives it an expected payoff of $\Phi^R(s)$ and gives E an expected payoff of $\Gamma^R(s)$.

(b) If the reputable VC is not willing, a non-reputable VC offers a transfer of τ^N and invests I_1 at time 0 in the firm in return for a debt contract with face value I_1. At time 1, if $s \geq \underline{s}^N$, the VC will invest an additional amount I_2 in return for a continuation contract that gives it an expected payoff of $\Phi^N(s)$ and gives E an expected payoff of $\Gamma^N(s)$.

We now discuss in more detail the factors that cause a given entrepreneur to prefer doing a deal with either a reputable or non-reputable VC. Since she can always seek offers from at least two non-reputable VCs, E can extract all of the "net relationship surplus" from such a deal, which is reflected in the above solution for the offered transfer τ^N. Note that this net surplus includes both the full value of the relationship and the expected value of future reputational rents that will accrue to the VC if the firm has a successful late exit with payoff π_3 (i.e., if the market learns that the VC is a skilled type). If a reputable VC wants E to accept its deal it must leave her with the same amount of expected surplus as she would get from transacting with a non-reputable VC, which is reflected in the above solution for τ^R. The reputable VC will be willing to make such an offer as long as it is left with positive net surplus, i.e., its payoff from making this offer and having it accepted is greater than the expected payoff to making no offer and waiting one period to enjoy its expected reputational rents, $\beta V^R(1-d)$.

The net relationship surplus that E extracts in a deal with a non-reputable VC can be expressed as

$$NRS^N \equiv \beta(1-e^N)I_1+e^N\left[\beta Pr[s<\underline{s}^N]\pi_1+\beta Pr[s\geq\underline{s}^N](\beta E[s|s\geq\underline{s}^N]\overline{\pi}-I_2)\right]-I_1-c(e^N) \quad (15)$$
$$+\beta^2 e^N Pr[s\geq\underline{s}^N]gE[s|s\geq\underline{s}^N]V^R(1-d).$$

The first line of the equation represents the value of the investment project itself. The second line represents the expected value of the reputational rents that will be generated if there is a successful late exit that yields π_3. This occurs only if the product is viable (probability e^N), $s\geq\underline{s}^N$ holds so that the late exit is attempted, the VC is a skilled type (probability g), and the state of nature is good (conditional expected probability $E[s|s\geq\underline{s}^N]$.

Since the reputable VC has to leave this amount of payoff to E in the time 0 negotiation to get a deal done, it will be willing to make such an offer only if the net relationship surplus from its deal with E exceeds that from E's potential deal with a non-reputable VC. The net relationship surplus with a reputable VC can be expressed as

$$NRS^R \equiv \beta(1-e^R)I_1+e^R\left[\beta Pr[s<\underline{s}^R]\pi_1+\beta Pr[s\geq\underline{s}^R](\beta E[s|s\geq\underline{s}^R]\pi_3-I_2)\right]-I_1-c(e^R) \quad (16)$$
$$+\left[\beta(1-e^R)+e^R(\beta Pr[s<\underline{s}^R]+\beta^2 Pr[s\geq\underline{s}^R])-\beta\right]V^R(1-d).$$

Again, the first line of the equation represents the surplus from just this project. The second line represents the change in the reputable VC's expected reputational rents due to potentially tying up its capital in this project for up to two periods. This term is negative overall, reflecting the fact that the reputable VC pays an implicit cost of continuing the project into the second stage. Since this implicit cost is increasing in V^R, so is the negative term. Given that continuation is more costly, it will be chosen less often when V^R is higher (i.e., $\underline{s}^R$ will be higher), which is costly to the project NPV represented in the first line. Thus, there is a conflict between the maximization of reputational rents and the maximization of project NPV, as discussed in the introduction.

To gain further intuition on these equations, note that we can rewrite (16) as follows by simplifying the second line:

$$NRS^R \equiv \beta(1-e^R)I_1+e^R\left[\beta Pr[s<\underline{s}^R]\pi_1+\beta Pr[s\geq\underline{s}^R](\beta E[s|s\geq\underline{s}^R]\pi_3-I_2)\right]-I_1-c(e^R) \quad (17)$$

$$-e^R \beta Pr[s \geq \underline{s}^R](1-\beta)V^R(1-d).$$

Here, the second line makes it clear that the direct effect of V^R on the net relationship surplus is coming from the probability $e^R Pr[s \geq \underline{s}^R]$ that the product will be viable and a late exit will be attempted, which causes a delay of one period in the reputable firm trying to re-enter the market, at cost $(1-\beta)V^R(1-d)$.

Put another way, an increase in V^R increases the strike price for the real option of the firm to continue the project toward a late exit. Indeed, we can re-write NRS^R again to highlight this even further:

$$NRS^R \equiv \beta(1-e^R)I_1 + e^R \beta \pi_1 - I_1 - c(e^R) \tag{18}$$

$$+e^R \beta Pr[s \geq \underline{s}^R](\beta E[s|s \geq \underline{s}^R]\pi_3 - \pi_1 - I_2 - (1-\beta)V^R(1-d)).$$

Here, the first line represents the value of the project with no real option for continuation, while the second line represents the value of the late exit continuation option including the cost of delayed market entry. Here it is clear that the term involving V^R enters the equation exactly like I_2, and can thus be considered an addition to the cost of exercise. This is a first-order negative effect of V^R on the net relationship surplus with a reputable firm.

The effect of V^R on the net relationship surplus with a non-reputed VC can be decomposed similarly:

$$NRS^N \equiv \beta(1-e^N)I_1 + e^N \beta \pi_1 - I_1 - c(e^N) \tag{19}$$

$$+e^N \beta Pr[s \geq \underline{s}^N](\beta E[s|s \geq \underline{s}^N]\overline{\pi} - \pi_1 - I_2 + \beta g E[s|s \geq \underline{s}^N]V^R(1-d)).$$

Here, the second line makes it clear that the direct effect of V^R is to increase the expected payoff of the real option (or reduce its strike price). Thus, there is a first-order positive effect of V^R on the net relationship surplus with a non-reputable firm.

In addition to these direct effects, V^R also affects the net relationship surplus through its interaction with the hold up problem, i.e., it affects the entrepreneur's effort, e, and, as noted above, the probability with which the project is continued, $\underline{s}$.

First consider how V^R affects the firm's relationship with a reputable VC. From (3) it is clear that $\underline{s}^R$ is increasing in V^R; intuitively, an increase in the value of reputation makes it less likely that the firm will attempt a late exit since the VC is better off diverting his attention to a new firm. From (5) it is clear that the entrepreneur's continuation payoff in the time 1 renegotiation is decreasing in V^R (note that the optimal α_1 does not change with V^R, so the comparative static is straightforward); an increase in the VC's outside option reduces the amount of surplus E can capture. Combining these observations and considering the FOC for E's effort, (12), it is clear that the RHS will be decreasing in V^R (Γ^R decreases in V^R for any s and $\Gamma^R > \pi_1 - I_1$). Thus, E's effort in a relationship with a reputable VC declines with the value of the VCs reputation. This is quite intuitive: a reputable VC has better outside options and will effectively bargain more forcefully in the renegotiation. Thus, the entrepreneur is more likely to be forced to sell out early, and is held up to a greater extent, reducing the incentive for effort.

Now consider how V^R affects the firm's relationship with a non-reputable VC. From (4) it is clear that $\underline{s}^N$ is decreasing in V^R. Since the value of reputation can only be enjoyed if the firm actually has a successful late exit, the VC will be eager to continue if there is a reasonable chance of success. Similarly, from (6) it is clear that E's continuation payoff in the renegotiation is increasing in V^R. Here, the potential creation of a reputation is a valuable by-product of a successful late exit, and the two parties will split that increase in expected surplus according to their respective bargaining powers. Finally, combining these observations and considering the FOC for E's effort, (12), it is clear that the RHS will be increasing in V^R (Γ^R decreases in V^R for any s and $\Gamma^R > \pi_1 - I_1$). Thus, E's effort in a relationship with a reputable VC increases with the value of the VCs potential reputation. We get exactly the opposite result here for two reasons: a higher value of reputation makes the parties more eager to continue the relationship, and it creates more potential ex post surplus for them to share, resulting in higher effort incentives as the holdup problem is relaxed. We summarize this discussion in the following result.

Proposition 2 *An increase in the value of reputation, V^R, results in a less efficient effort choice by E in a relationship with a reputable VC, but a more efficient effort choice in a relationship with a non-reputable VC.*

Thus, in addition to the direct negative effect of V^R on NRS^R, there are indirect negative effects as e^R falls and $\underline{s}^R$ rises. Similarly, there are indirect positive effects on NRS^N from the increase in e^N and the decrease in $\underline{s}^N$. In both cases, these indirect effects reinforce the direct effects of V^R on the relationship surplus.

We now discuss how these forces combine to determine the optimal choice of partner. First note that when $V^R = 0$ and $\pi_3 = \pi_2$, i.e., when there is no value of having a reputation and no benefit from having a skilled VC, we have $NRS^N = NRS^R$. Thus, dealing with either VC is the same. However, when a skilled VC has an advantage in value creation ($\pi_3 > \pi_2$), there will be more surplus available in that relationship, so the reputable VC will always be chosen if $V^R = 0$. However, as shown above, when $V^R > 0$ the reputable VC places less value on the continuation option and also bargains more forcefully ex post, which reduces the entrepreneur's effort in such a relationship. At the same time, the prospect of creating a valuable reputation increases the value of the continuation option for a non-reputable VC, which also causes it to bargain less forcefully and increases entrepreneurial effort. These tradeoffs determine the optimal choice of VC type for non-zero V^R.

To help formalize these ideas, consider the following result.

Proposition 3 *NRS^N is increasing in V^R and π_2. NRS^R is decreasing in V^R for sufficiently small V^R and is unaffected by π_2. Furthermore, for all $\pi_2 < \pi_3$, there exists a $V^R > 0$ such that $NRS^R = NRS^N$.*

These comparative statics are intuitive given the above results. They imply that, in general, entrepreneurs will do deals with reputable VCs when the value of reputation is low, but will switch to non-reputable VCs for higher values of reputation. In addition, the larger is the wedge in payoff from skill, the greater is the reputational value that would be required to push the deal to a non-reputable VC. This result is formalized in the following proposition.

Proposition 4 *Assume $\pi_2 < \pi_3$. Let $\underline{V}^R$ be the smallest V^R such that $NRS^R = NRS^N$. Then $\underline{V}^R$ is greater the smaller is π_2.*

Since the comparative static for NRS^R in V^R is not proven to be universal, we cannot guarantee that there is always a unique cutoff level of V^R such that reputable VCs do deals below the cutoff and non-reputable VCs do deals above the cutoff (though this has been true in all simulations we have attempted). However, since $NRS^R > NRS^N$ when $\pi_2 < \pi_3$ and $V^R = 0$, it is clear that a non-reputable VC will not be able to do the deal unless the value of reputation exceeds its smallest value that makes the net surpluses equal, i.e., for some $V^R > \underline{V}^R$. Intuitively, this requires a greater value of reputation the larger is the gap in successful late exit payoffs between the skilled and unskilled VCs.

4. A Dynamic Model with Endogenous Value of Reputation

A limitation of the preceding static analysis is that the value of a reputation for skill is treated as exogenous to the details of the contracting relationship. In reality, this value will (at least partially) derive from being recognized as skilled by future entrepreneurs with similar projects. To account for this, we now embed our static contracting model in a dynamic, discrete time model of the interaction of many VCs and entrepreneurs over an infinite time horizon. We derive a steady-state equilibrium in which the value of reputation is fully endogenized and show that equilibria exist where many firms choose not to do deals with reputable VCs even when they are available.

We assume a continuum of firms of mass one enters the market each period in search of funding. The firms' projects die before the beginning of the next period if not funded. There are two types of firms: high potential (H) and low potential (L). The two types are distinguished by the late exit value they can achieve if funded by a skilled VC, $\pi_3^H > \pi_3^L$. As in the base model, both types will be worth π_2 in a successful late exit if funded by an unskilled VC. Thus, they differ in the extent to which VC skill can *increase* their late exit payoff — high potential firms have a larger marginal impact of VC skill. Each firm has an exogenous probability γ of being high potential. Since there are a continuum of firms entering the market each period, γ is also the constant mass of new high potential firms each period. Firm types are known by all players once the firms enter the market. All parameters of the model are constant over time.

When a firm enters the market it is matched to two non-reputable VCs (as in the static model). In addition it may be matched to a reputable VC. We assume for now that the mass of reputable VCs available in a period, denoted η, is greater than the mass of high potential firms, γ. We then verify that this holds for all parameters we study when we derive the steady state equilibrium. These are the more interesting equilibria since they have some reputable VCs that may have to consider deals with low potential firms (in equilibria with $\eta < \gamma$, it is generally the case that all reputable VCs do deals with high potential firms at all times). Since the mass of reputable VCs exceeds the mass of high potential firms, we assume that each high potential firm is matched to one reputable VC in addition to its two non-reputable VCs. The remaining reputable VCs are matched individually to low potential firms (each of which is also matched to two non-reputable VCs) until either the mass of reputable VCs or the mass of low potential firms is exhausted. If the mass of reputable VCs is exhausted first, the remaining low potential firms are matched just to two non-reputable VCs. In our reduced form matching structure, two or more reputable VCs are never matched to the same firm. This allows us to focus on the question of whether firms will ever sign contracts with non-reputable VCs when a reputable VC is available to them. The model could easily be extended to consider probabilistic competition among reputable VCs.

Once firms and VCs are matched, the contracting game and relationship play out over two periods exactly as in the static contracting model. Once a relationship ends (through liquidation, an early exit, or a late exit), the firm exits the market and the VC attempts to re-enter the market, but, as before, dies with probability d before reaching the market. Also as before, any VC that fails to sign a deal can attempt to re-enter the market to search for a match the following period. We assume there is always a sufficient mass of non-reputable VCs (a mass of at least two) available.

Given the assumption of a steady state equilibrium, the mass of *previously* reputable VCs re-entering the market at a given period will be constant at $(1-d)\eta$. To maintain η at its constant level, therefore, the number of *newly* reputable VCs that successfully reach the market must exactly offset the lost quantity of previously reputable VCs, $d\eta$. Newly reputable VCs will be those previously non-reputable VCs whose firms have just completed a successful late exit and realized π_3^j, where $j \in \{H, L\}$. We guess (and verify later) that all high potential firms end up signing contracts with reputable VCs. Thus, newly reputable VCs must be emerging from relationships with low potential firms. Letting ϵ represent the mass of non-reputable VCs entering relationships with low potential firms each period, the following equation then defines the relationship that the mass of newly reputable VCs reaching the market each period must satisfy

$$d\eta = (1-d)\epsilon g e_L^N Pr[s \geq \underline{s}_L^N] E[s | s \geq \underline{s}_L^N], \tag{20}$$

where the subscripted L on variables introduced in the static model indicates a low potential firm. The LHS gives the outflow of previously reputable firms that try but fail to make it back to the market, and the RHS gives the inflow of newly reputable firms that reach the market. Of the mass ϵ of non-reputable VCs who entered relationships two periods previously, proportion g are actually skilled, they have probability $e_L^N Pr[s \geq \underline{s}_L^N]E[s|s \geq \underline{s}_L^N]$ of creating a viable product and successfully completing a late exit, and $(1-d)$ of them will not die before they re-enter the market. Any other non-reputable VCs (those whose relationships end early or fail to get a successful late exit) either re-enter the market as non-reputable firms or leave the market (if they are found to be unskilled).

The size of the mass ϵ of non-reputable VCs who do deals with low potential firms can vary from zero (if $\eta \geq 1$ and all firms paired with reputable VCs do deals with those VCs) to $1-\gamma$ (if reputable VCs *only* do deals with high potential firms). Generically, some low potential firms may end up doing deals with reputable VCs that they are paired with, while others could do deals with non-reputable VCs even though they are matched to a reputable VC. To deal with the range of possibilities, we define the variable ρ as the proportion of reputable VCs *not* paired with high potential firms that end up doing deals. Thus, the total number of deals done by reputable VCs will equal $\gamma + \rho(\eta - \gamma)$ — mass γ does deals with high potential firms, and mass $\rho(\eta-\gamma)$ does deals with low potential firms. Note that if $\eta > 1$, ρ can vary only up to the point where $\gamma + \rho(\eta - \gamma) = 1$, i.e., its maximum in those cases is $\frac{1-\gamma}{\eta-\gamma}$ (which we impose below). As such, let $\overline{\rho}$ be the maximum possible value of ρ for a given set of parameters. The total number of deals done by non-reputable VCs will be $\epsilon = 1 - \gamma - \rho(\eta - \gamma)$. Using this in (20) and solving for η yields

$$\eta = \frac{\frac{1-d}{d} g(1-\gamma+\rho\gamma) e_L^N Pr[s \geq \underline{s}_L^N]E[s|s \geq \underline{s}_L^N]}{1 + \rho \frac{1-d}{d} g e_L^N Pr[s \geq \underline{s}_L^N]E[s|s \geq \underline{s}_L^N]}. \tag{21}$$

It remains to determine the value of being a reputable VC, or V^R, in a steady-state equilibrium. First we derive an expression for the expected payoff to the VC from a deal with a high or low potential firm (excluding the value of reputation it will enjoy once this relationship is over). For a deal with a firm of type $j \in \{H, L\}$, this is

$$\theta_j^R = -\tau_j^R - I_1 + \beta(1-e_j^R)I_1 + e_j^R \left[\beta Pr[s < \underline{s}_j^R]I_1 + Pr[s \geq \underline{s}_j^R](\beta E[\Phi_j^R | s \geq \underline{s}_j^R] - \beta^2 V^R(1-d))\right]. \tag{22}$$

Note that $E[\Phi_j^R|s \geq \underline{s}_j^R]$ is a conditional expected continuation payoff resulting from the time 1 re-negotiation (if such is reached), which includes the value of re-entering the market as a reputable VC at time 2 with probability $(1-d)$, thus, the expected value of realizing that reputational value is subtracted so that only the value coming from the relationship itself is included.

When a reputable VC enters the market it has probability $\frac{\gamma}{\eta}$ of being matched with a high potential firm and doing a deal, probability $\frac{\rho(\eta-\gamma)}{\eta}$ of being matched with a low potential firm and doing a deal, and probability $(1-\frac{\gamma}{\eta}-\frac{\rho(\eta-\gamma)}{\eta})$ of not doing a deal (either because it is not matched or because it is matched to a low potential firm that chooses to deal with a non-reputable VC). The value of arriving at the market as a reputable firm is therefore

$$V^R = \frac{\gamma}{\eta}\left[\theta_H^R + (1-d)V^R(\beta(1-e_H^R) + \beta e_H^R Pr[s < \underline{s}_H^R] + \beta^2 e_H^R Pr[s \geq \underline{s}_H^R])\right] \tag{23}$$

$$+\frac{\rho(\eta-\gamma)}{\eta}\left[\theta_L^R + (1-d)V^R(\beta(1-e_L^R) + \beta e_L^R Pr[s < \underline{s}_L^R] + \beta^2 e_L^R Pr[s \geq \underline{s}_L^R])\right]$$

$$+(1-\frac{\gamma}{\eta}-\frac{\rho(\eta-\gamma)}{\eta})\beta V^R(1-d).$$

To understand this equation, first consider the first line. With probability $\frac{\gamma}{\eta}$ the VC is matched to a high potential firm and does a deal. In this case, its continuation payoff from the relationship itself is θ_H^R. In addition, it gets the value of returning to the market with probability $(1-d)$ as a reputable firm. However, this can happen in various different circumstances: with probability $(1-e_H^R)$ it happens at time 1 due to a non-viable product, with probability $e_H^R Pr[s < \underline{s}_H^R]$ it happens at time 1 due to a viable product but s that is too low to justify continuation, and with probability $e_H^R Pr[s \geq \underline{s}_H^R]$ it happens at time 2 after a (successful or unsuccessful) late exit. The second line is similar, but for a relationship with a low potential firm. The third line represents the case where no deal is struck, so the VC must just wait one period and then try to re-enter the market.

Equation (23) is clearly an implicit equation in V^R that cannot be solved explicitly since many of the endogenous quantities on the RHS depend on V^R, as seen in our solution of the static contracting model. Thus, to solve for the steady state equilibrium we use numerical simulation.

A key question for finding an equilibrium is whether ρ will have an internal or corner solution. In order for an internal solution to exist, reputable VCs that are matched to low potential firms must be indifferent between doing a deal and not doing a deal at terms attractive to the entrepreneur. Following the logic from the previous section, this will hold when $NRS_L^R = NRS_L^N$ (using the now endogenous value of V^R from (23)), i.e., when the net relationship surplus for the reputable VC in a deal with a low potential firm is equal to the net relationship surplus for a non-reputable VC with the same firm. An equilibrium with an internal solution for ρ must therefore simultaneously solve both (23) and $NRS_L^R = NRS_L^N$ for some $\rho \in (0, \overline{\rho})$. Alternatively, if the simultaneous solution of those equations yields a $\rho < 0$, then a corner solution at $\rho = 0$ exists. If it yields a $\rho > \overline{\rho}$, then a corner solution at $\rho = \overline{\rho}$ exists. In either case, the equilibrium is characterized by ρ and the solution to (23). As discussed in the introduction, we refer to equilibria with a $\rho = \overline{\rho}$ corner solution as a "type 1" equilibrium, those with an interior solution for ρ a "type 2" equilibrium, and those with a $\rho = 0$ corner solution as a "type 3" equilibrium.

Whenever $\rho < \overline{\rho}$ in equilibrium (a type 2 or 3 equilibrium), there is a mass of reputable VCs that have to "sit on the sidelines" and forego doing a deal despite the fact that they are matched to a firm. Such equilibria are of particular interest because the reason for such an effect is the same as discussed in the previous section — firms who cannot benefit as much from the VC's skill may be better off contracting with a non-reputable VC who will more highly value the continuation option and renegotiate less aggressively at time 1. The difference here is that V^R is endogenous, and is derived entirely from the rents that the VC can capture from future deals because of its reputation. Thus, based on the intuition from the static model, factors that raise V^R would seem to amplify the "sitting on the sidelines" effect and vice versa, but the interactions can become quite complicated. We explore these interactions in detail in the simulations below.

4.1. Steady State Equilibrium Simulations

To illustrate these results we start with a base set of parameters and map equilibrium outcomes as two key parameters are allowed to vary: γ, the proportion or mass of high potential firms, and π_3^L, the late exit payoff achievable for a low potential firm with a reputable VC. The higher is γ, the more likely it is that a reputable VC will be able to do a deal with a high potential firm each period. The higher is π_3^L, the closer are low potential firms to high potential firms. We parameterize the effort cost function $c(e)$ as $c(e) = \frac{1}{2}be^2$. The other parameters are set at base values as follows: $d = 0.05$, $\lambda = 0.5$, $\beta = 0.98$, $I_1 = 2$, $I_2 = 5$, $\pi_1 = 15$, $\pi_2 = 40$, $\pi_3^H = 60$, $g = 0.3$, and $b = 20$.

We first map the equilibrium ρ as γ varies between 0.05 and 0.65 and π_3^L varies between 42 and 52. See the right side of Figure 2, in which γ is increasing going up the figure (away from the reader) and π_3^L is increasing to the right. The flat elevated area in the lower right of the figure has $\rho = 1$,

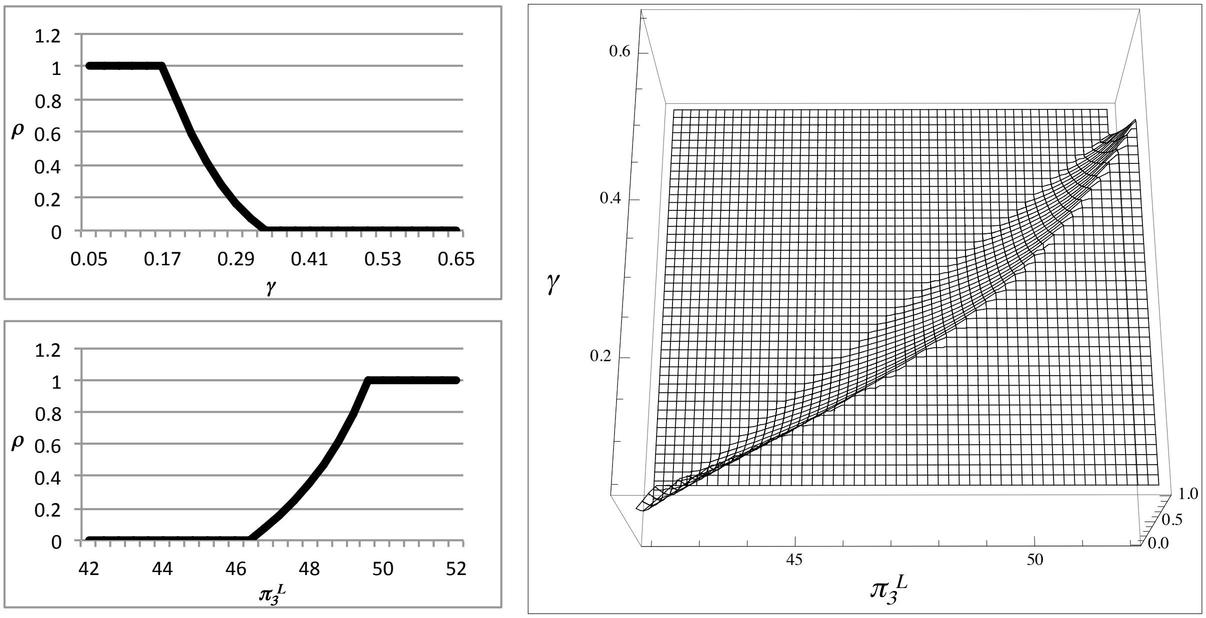

Figure 2
Equilibrium level of ρ for varying levels of γ and π_3^L.

and thus represents type 1 equilibria where reputable VCs do deals with every firm to which they are matched. The flat low area in the upper left has $\rho = 0$, and thus represents type 3 equilibria where all reputable VCs that are matched to low potential firms sit on the sidelines, i.e., are unable to enter into deals. The area in between has interior solutions for ρ, so are type 2 equilibria. The two graphs to the left side of the figure give cross-sections of the 3D surface as one variable, γ or π_3^L, is held constant (at $\gamma = 0.3$ or $\pi_3^L = 47$). From the top graph, it is easy to see that as γ increases into the the area with type 2 equilibria, ρ declines smoothly toward zero. Notably, then, as γ increases, reputable VCs are less likely to be able to enter into deals with low potential firms. This is quite intuitive—a high γ implies a high value of reputation, which reduces the value of the continuation option for the reputable VC and makes the hold up problem worse, and heightens the incentive of non-reputable VCs to become reputable. On the other hand, as shown in the lower left graph, as π_3^L increases, reputable VCs are more likely to be able to enter into deals with low potential firms. When low potential firms are comparatively "good," the importance of taking advantage of VC skill is increased, making them more attractive to deal with.

Now consider how this equilibrium structure translates into an endogenous value for reputation, V^R. Figure 3 plots the value of reputation as γ and π_3^L vary as before. Not surprisingly, V^R in generally increasing in γ (see the upper left graph) — the more high potential firms there are for reputable VCs to be matched with, the more they will be able to take full advantage of their skill (and the more rents they can therefore extract in expectation). This holds everywhere except in the region with type 2 equilibria where ρ is interior, in which case V^R is constant as γ changes. This is due to the adjustment of ρ to keep reputable VCs indifferent over doing deals with low potential firms within this class of equilibria.

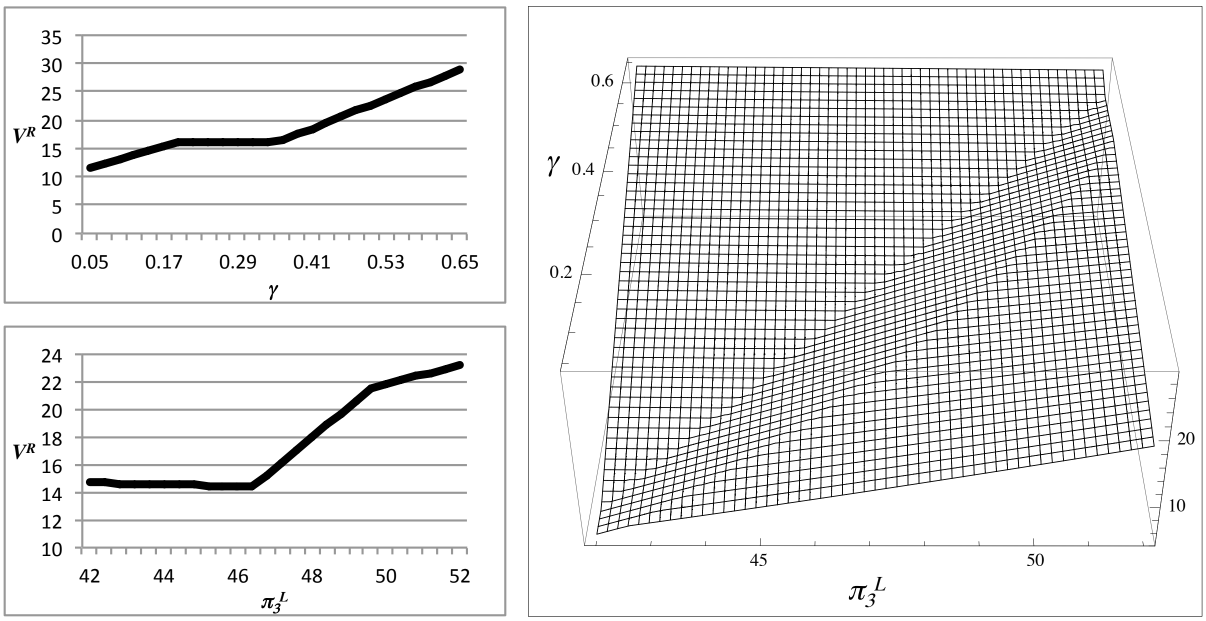

Figure 3
Equilibrium level of V^R for varying levels of γ and π_3^L.

In the lower right part of the 3D graph, where reputable VCs are able to enter into deals with low potential firms whenever so matched in type 1 equilibria, there is another intuitive result that V^R increases with π_3^L (also see the right section of the lower left graph)— when reputable firms find it profitable to do deals with low potential firms, they can capture more surplus the higher is their marginal impact on firm value. However, this is subtly reversed in the upper left part of the 3D graph (or the left section of the lower left graph), where equilibria are of type 3 and reputable VCs are *not* able to do deals with low potential firms when so matched. Here, V^R is actually slightly decreasing with π_3^L due to increased effort by entrepreneurs in relationships with non-reputable VCs.

The magnitudes in Figure 3 are also interesting to consider. Across these parameters the value of reputation varies from a low of around 4.5 to a high of around 29. For comparison, the value generated by a single reputable VC's relationship with a single high potential firm varies from 14.5 to 15. Thus, what our model reveals is that the value of reputation is tightly constrained relative to the value that skill can generate in this type of model, where reputable firms have superior opportunities and non-reputable firms are constantly attempting to gain reputation to be able to compete for high potential relationships in the future. As an additional comparison, we considered a modification of the model to remove the competition effect and estimate the value of reputation based solely on skill. In this modified model, firms that are matched to reputable VCs are not matched to non-reputable VCs, and therefore do deals with the reputable VCs as long as they are positive NPV. Under the assumption that the VCs make take-it-or-leave-it offers (but up-front transfers cannot be negative), the value of reputation varies from a low of 31 to a high of 75, and is nearly 7 times higher than in our main model in certain parameter configurations. The large differences in reputation value are driven by a number of related forces. First, as a result of reputable VCs' higher outside options as well as non-reputable VCs' strong desire to become reputable (and resulting willingness to share the expected reputational rents), some low potential entrepreneurs choose to deal with non-reputable VCs, which leads to a loss of potentially valuable relationships for reputable VCs. This leads to an amplification effect: because non-reputable VCs do more deals, more will inevitably have successful late exits and have their skill discovered by the market, which increases the supply of reputable VCs and thus future competition over high potential entrepreneurs.

Now consider how the steady-state mass of reputable types varies across the parameter space. Figure 4 plots this mass, η, as γ and π_3^L vary as above. Note first that in the lower right region, where equilibria are of type 1, there is little variation in η as the parameters change. However, as γ increases into the type 2 equilibrium range, where some reputable VCs sit on the sidelines while non-reputable VCs do more deals, there is a rapid increase in η as ρ declines. This reflects the fact that there is an increasing opportunity for non-reputable VCs to do deals and gain reputation. However, once ρ reaches its minimum at zero and the equilibria are of type 3, η starts to decline as γ continues to rise. Once all low potential deals are being done by non-reputable VCs, an increase in γ (and therefore the number of deals being done by reputable VCs) starts to reduce the number of deals done by non-reputable VCs, and therefore the inflow of newly reputable VCs declines, reducing the steady state mass. The mass of reputable VCs is maximized near the lower left corner, where γ is high enough that most low potential deals are done by non-reputable VCs, but not so high that the total mass of low potential firms is small. Notably, the mass η reaches as high as 1.8 in that area, so that there are nearly twice as many reputable VCs as there are *firms overall*, but fewer reputable VCs are able to do deals.

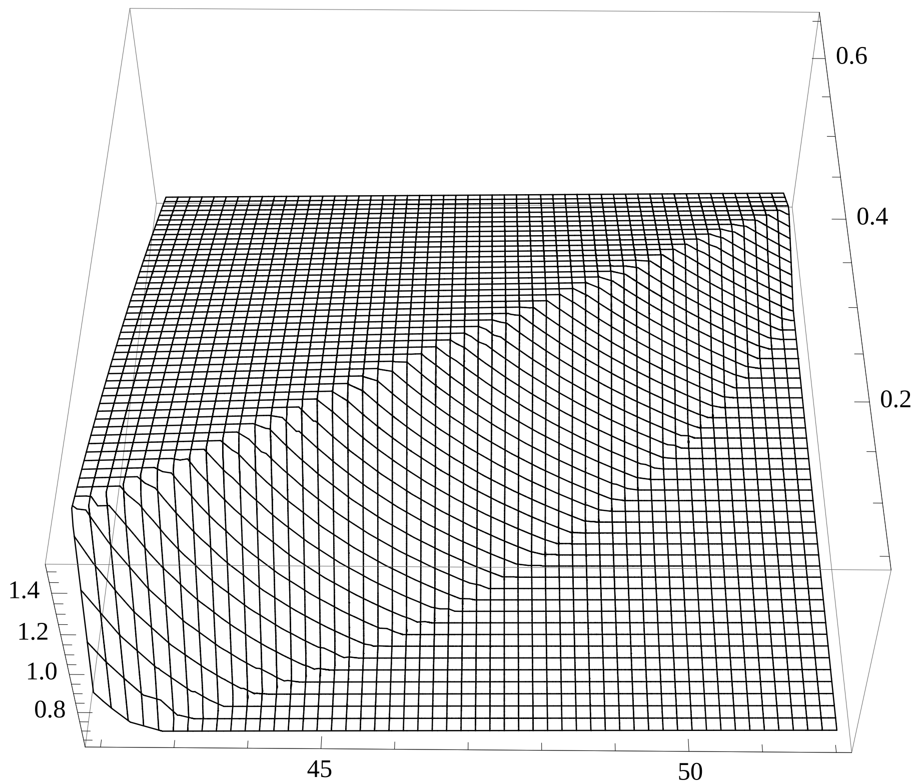

Figure 4
Equilibrium level of η for varying levels of γ and π_3^L.

This intuition leads directly to Figure 5, which plots the mass of reputable VCs sitting on the sidelines in equilibrium. The patterns follow more or less exactly those from the previous graph: the mass of reputable VCs sitting on the sidelines is high when non-reputable VCs are able to do a lot of deals. In this area of the graph, there is a large inflow of newly reputable VCs into the market each period, and a small number of high potential firms available for reputable VCs to do deals with. This, of course, coincides with relatively low values of reputation.

Our model also allows us to characterize differences in initial contracting terms across different

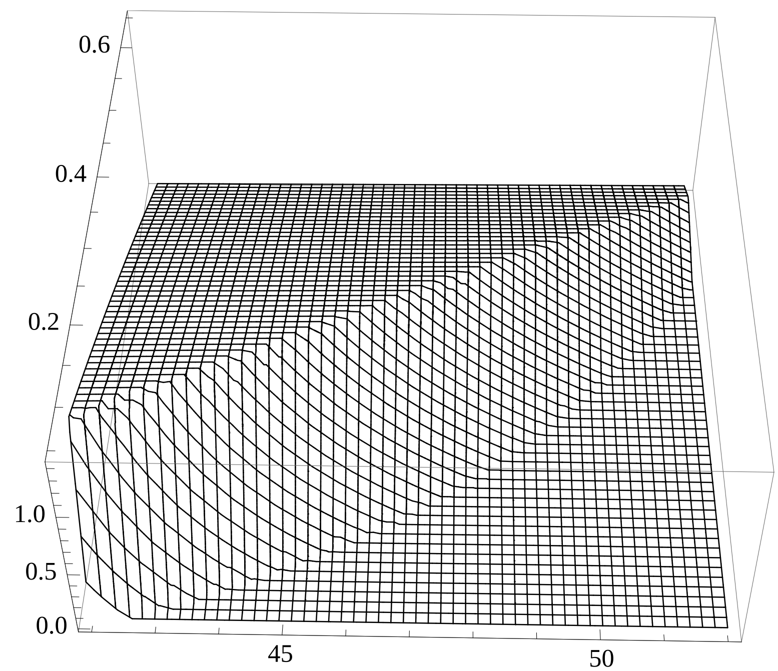

Figure 5
Equilibrium mass of reputable VCs sitting on the sidelines for varying levels of γ and π_3^L.

types of VCs. As noted in the introduction, Hsu (2004) finds that firms accept discounts averaging from 10-14% for equity sold in their initial seed rounds in order to do deals with reputable VCs. In our model, all initial contracts are identical debt contracts with common amounts invested in the firm, so the analogue to Hsu's result would be captured by any difference in ex ante transfers. Figure 6 graphs the ratio of the transfer offered to low potential firms by reputable VCs to that offered by non-reputable VCs (i.e., $\frac{\tau_L^R}{\tau_L^N}$) as the proportion of high potential firms, γ, varies.

Consistent with Hsu (2004), on the left-hand side of the graph, where γ is low, reputable VCs pay a significantly lower transfer than non-reputable VCs for the same initial contract. In this area of the graph, both of these transfers are observed in equilibrium despite the fact that reputable VCs do deals with all firms to which they are matched since the mass of reputable VCs is below one and some low potential firms are only matched to non-reputable VCs. Notably, as γ (and therefore V^R) increases, the size of the discount shrinks, ultimately disappearing once V^R becomes high enough that the equilibrium switches from type 1 to type 2. As V^R increases, the downsides of reputation become more prominent, making reputable VCs less attractive to entrepreneurs, and non-reputable VCs are willing to pay more in an attempt to become reputable. Thus, somewhat

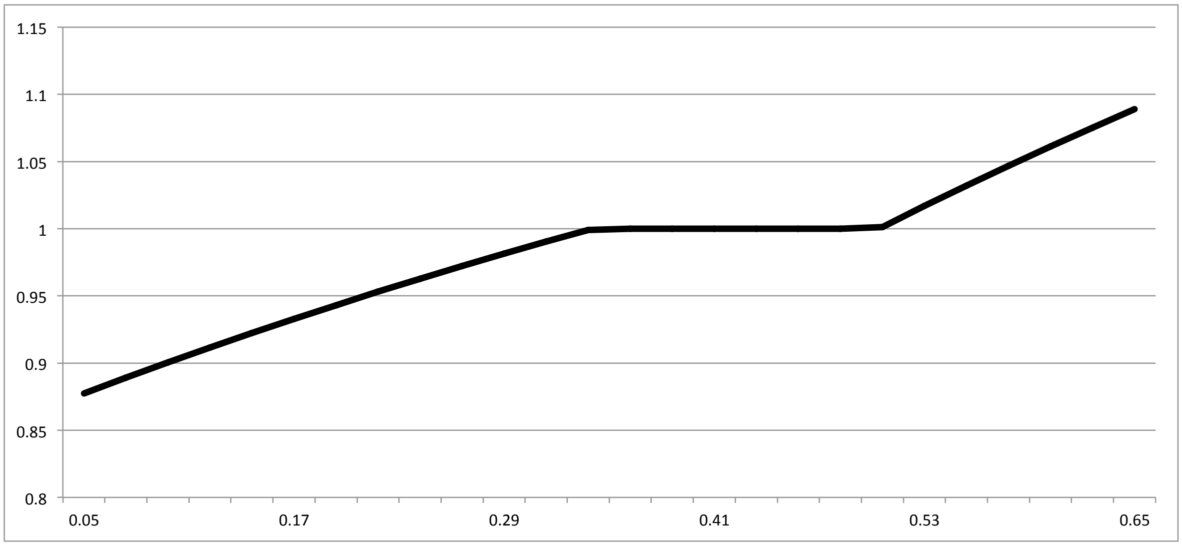

Figure 6
Ratio of transfers offered to low potential firms by reputable versus non-reputable VCs for different values of γ.

counter-intuitively, discounts paid by reputable VCs relative to non-reputable VCs will be largest when the value of their reputation is smallest. On the far right of the figure, the reputable VC is actually willing to pay a premium, but in our model this premium is never paid because it is not enough to convince the entrepreneur to deal with the reputable VC (the equilibrium is of type 3). Note that we do not provide a similar figure for the relative offers made to high potential firms since these firms always do deals with reputable VCs, however the pattern is similar...reputable VCs always attract high potential entrepreneurs with transfers that are far lower than non-reputable VCs are willing to offer, but the ratio rises as γ, and therefore V^R, increases.

Figure 7 graphs the same ratio as π_3^B varies. Here, the left side of the figure corresponds to type 3 equilibria, where reputable VCs offer premia that are not accepted by entrepreneurs. As π_3^B increases, and the equilibrium shifts to type 2 and then type 1, this shifts to a discount that grows with π_3^B. Not surprisingly, the more important is skill to a low potential firm, the more attractive is a reputable VC and the lower is the relative transfer they have to pay to attract the entrepreneur.

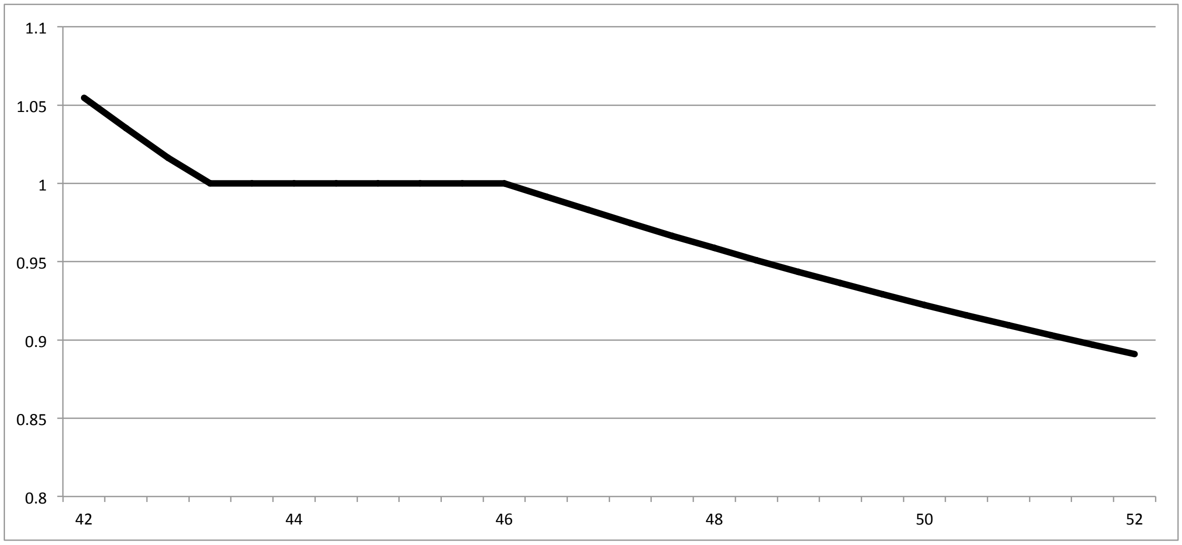

Figure 7
Ratio of transfers offered to low potential firms by reputable versus non-reputable VCs for different values of π_3^B.

4.2. Social Efficiency

In our simulated economy, many low potential firms who could benefit from VC skill ultimately choose not to partner with a reputable VC. As explained above, this is due to competition from non-reputable VCs, who are willing to pay more to low potential entrepreneurs because of their higher valuation of the continuation option and their desire to become reputable. This could clearly have a negative impact on social welfare for two reasons: 1) some direct surplus may be lost in projects that are financed by non-reputable VCs, and 2) excess resources may be devoted to creating more reputable VCs, as non-reputable VCs privately "over-value" reputational rents relative to the social optimum.

Our model allows us to attempt a quantification of this efficiency impact. To do so as parsimoniously as possible, we make a simple modification in the model: we assume that any low potential firm that is matched to a reputable VC loses access to non-reputable VCs.[8] With this assumption,

[8]For bargaining at time 0, we assume E has all of the bargaining power, so makes a take-it-or-leave-it offer to the reputable VC. This bargaining power allocation is different from the modified model discussed in the previous section, where we assumed the VC makes a take-it-or-leave-it offer. There the intent was to illustrate how high the value of reputation could be, which is maximized by giving reputable VCs more bargaining power. Here, the intent

the firm will make a deal with the reputable VC as long as their net relationships surplus is positive, whereas in our base model above it had to (weakly) exceed the net relationship surplus with a non-reputable VC. We thus eliminate the competitive impact of non-reputable VCs and maximize incidences of successful relationships for reputable VCs. However, this of course will also impact the steady state number of reputable VCs — fewer non-reputable VCs now get the chance to gain reputation, leading to fewer reputable VCs in steady state. This potentially has a negative impact on social welfare. However, the simulations below show that this effect is generally overwhelmed by the positive effect of reduced competition.

To measure social welfare in each model (the"main" model above and the modified "no competition" model), we calculate the aggregate net present value (NPV) of projects undertaken in the steady-state equilibrium, denoted NPV^A. Note that the NPV for each project includes only the returns to the project itself, not any element of reputational rents (which do not impact social surplus). Thus, let NPV_i^j denote the project NPV for a firm of type $i \in \{L, H\}$ with a VC of type $j \in \{N, R\}$, which corresponds to the first line of either equation (15) or (16) as appropriate. Then aggregate NPV for either model is derived as follows:

$$NPV^A = \gamma NPV_H^R + \rho(\eta - \gamma)NPV_L^R + (1 - \gamma - \rho(\eta - \gamma))NPV_L^N. \tag{24}$$

The first part is due to the mass of high potential firms funded by reputable VCs, the second part is due to the mass of low potential firms funded by reputable VCs, and the third part is due to the mass of low potential firms funded by non-reputable VCs. For the main model, ρ is given endogenously as in the solutions above. For the no competition model, ρ becomes one as long as low potential firms have non-negative net surplus in relationships with reputable VCs (which will be true in all our simulations).

For ease of exposition we provide comparative simulations in which only a single variable is changed (γ or π_3^B) while holding the other constant (at $\gamma = .3$ or $\pi_3^B = 46$). First consider how the no competition model compares to the main model with respect to η, the mass of reputable VCs in steady state equilibrium. Figure 8 graphs the level of η as γ changes for both models, with the main model represented by the solid line and the no competition model represented by the dashed

is to illustrate how high social efficiency can be, which is maximized by giving entrepreneurs more bargaining power.

line.

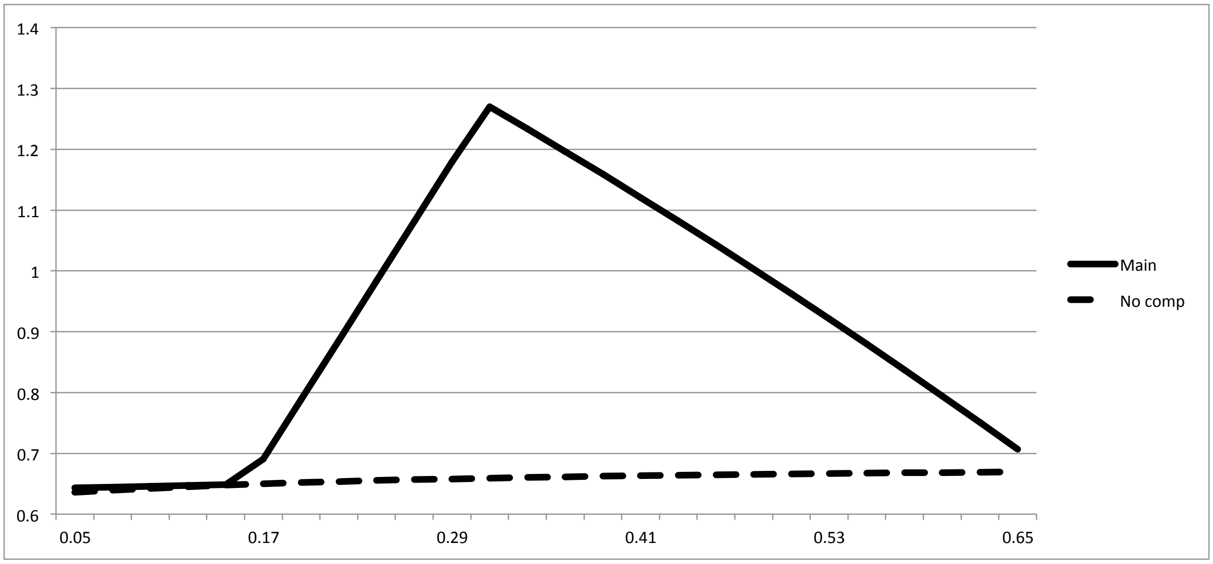

Figure 8
Equilibrium level of η for varying levels of γ.

As the figure shows, the mass of reputable VCs in the no competition model changes only slightly as γ increases. However, in the main model it spikes upwards as ρ drops from one toward zero over the range of type 2 equilibria as many more non-reputable VCs capture deals that would otherwise have been done by reputable VCs, and thus increase the supply of newly reputable VCs. This reverses, however, as γ continues to rise into the region with type 3 equilibria, as the higher ratio of high potential firms causes more deals to be done by reputable VCs. Strikingly, the no competition model has many fewer reputable VCs in steady state equilibrium over a very wide parameter space. Note that the mass of reputable VCs is slightly increasing in γ for the no competition model, which is due to increased effort by entrepreneurs in relationships with non-reputable VCs.

Figure 9 performs a similar exercise but this time varies π_3^B. Here, again, the mass of reputable VCs is quite stable for the no competition model. However, for the main model, at low levels of π_3^B the mass of reputable VCs is quite high, as in this region equilibria are of type 3 and $\rho = 0$, so that all low potential firms do deals with non-reputable VCs (skill is not so important, so non-reputable VCs have an advantage). However, as π_3^B rises and skill becomes more important to low potential firms, ρ starts to rise and fewer newly reputable VCs are created, so that it converges finally to nearly the same level as the no competition model.

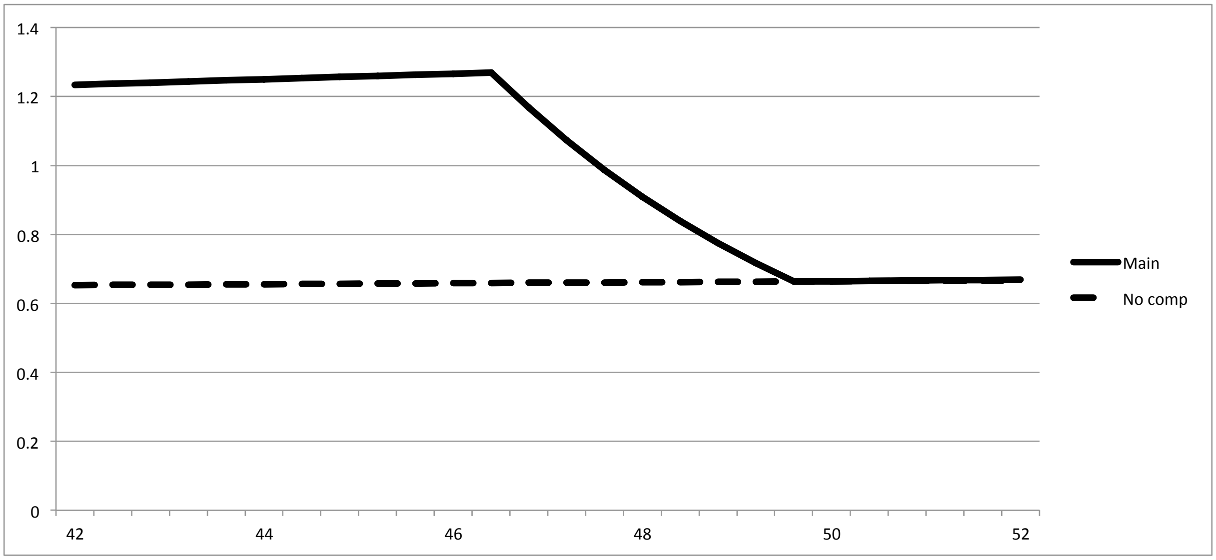

Figure 9
Equilibrium level of η for varying levels of π_3^B.

Next consider how the models compare with respect to the total mass of low potential firms that do deals with reputable VCs. Indeed, the main point of considering the no competition model is to increase aggregate surplus by making better use of skill. Figure 10 graphs the mass of low potential firms doing deals with reputable VCs across the two models as γ changes. In both models, as expected, the mass of low potential firms doing deals with reputable VCs falls as γ rises since the total mass of low potential firms is falling. Notably, though, it falls much faster in the main model as ρ starts to drop below one in the region with type 2 equilibria and non-reputable VCs compete away many low potential deals.

Figure 11 performs a similar exercise but this time varies π_3^B. At low levels of π_3^B we have type 3 equilibria with $\rho = 0$, so that reputable VCs are not doing deals with any low potential firms in the main model. However, as π_3^B rises and skill becomes more important to low potential firms, ρ starts to rise and more deals are done by reputable VCs, so that it converges finally to approximately the same level as the no competition model as the equilbria become type 1.

Finally, consider social welfare across the two models, as measured by NPV^A. Figure 12 graphs NPV^A for the two models as γ changes. At low γ, where $\rho = 1$ in type 1 equilibria and reputable VCs are doing all deals they are matched to, the two models have nearly identical social welfare. However, as γ rises into the region with type 2 equilibria and non-reputable VCs start stealing away

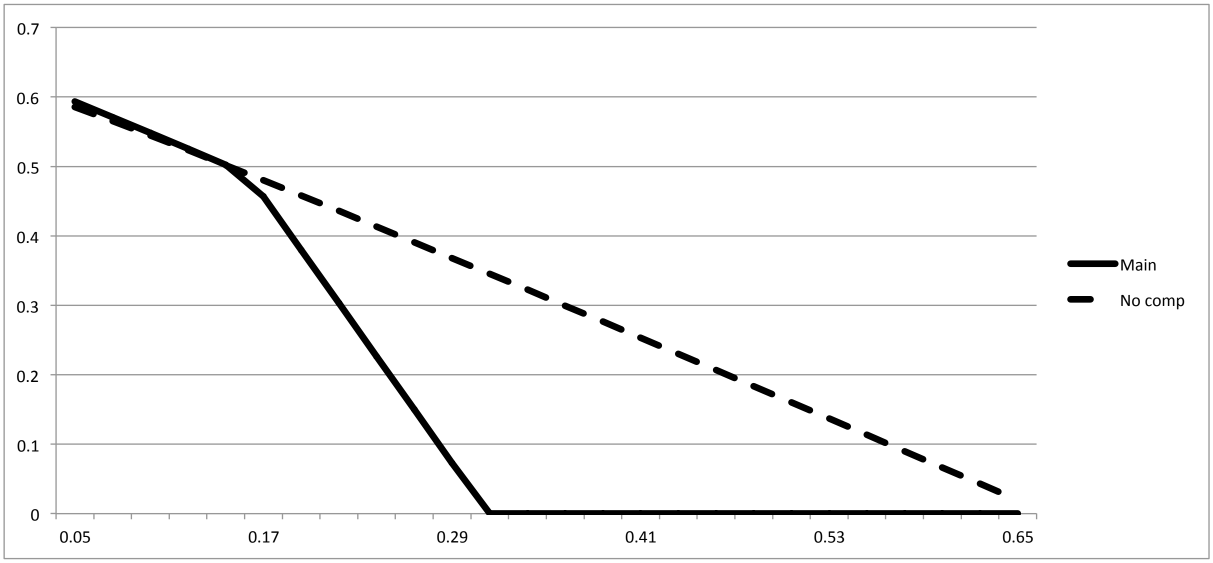

Figure 10
Equilibrium mass of low potential firms doing deals with reputable VCs for varying levels of γ.

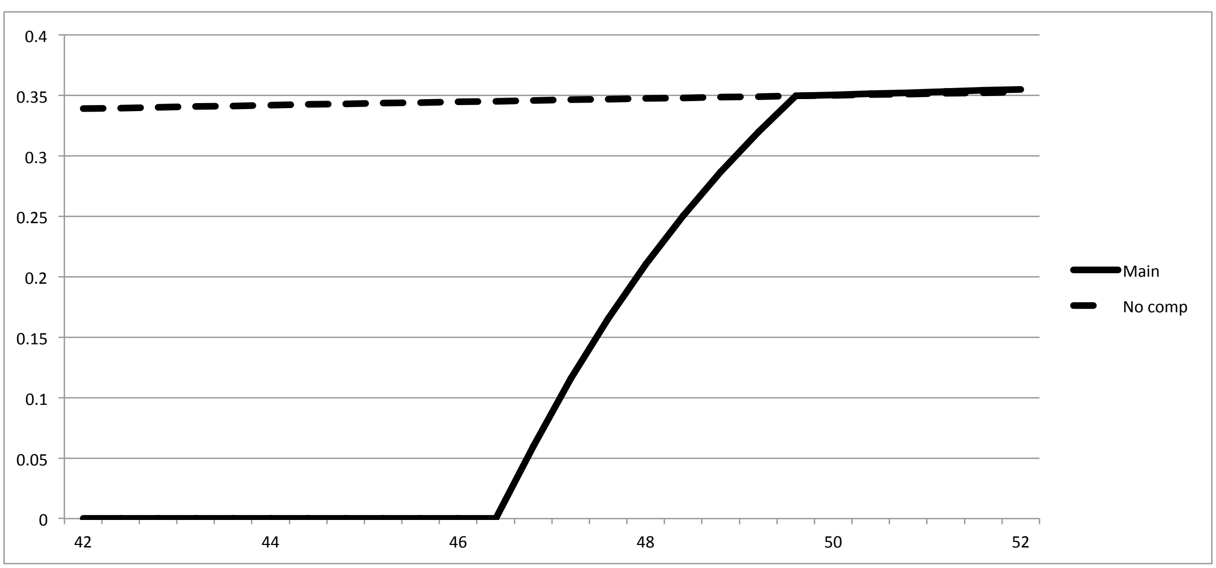

Figure 11
Equilibrium mass of low potential firms doing deals with reputable VCs for varying levels of π_3^B.

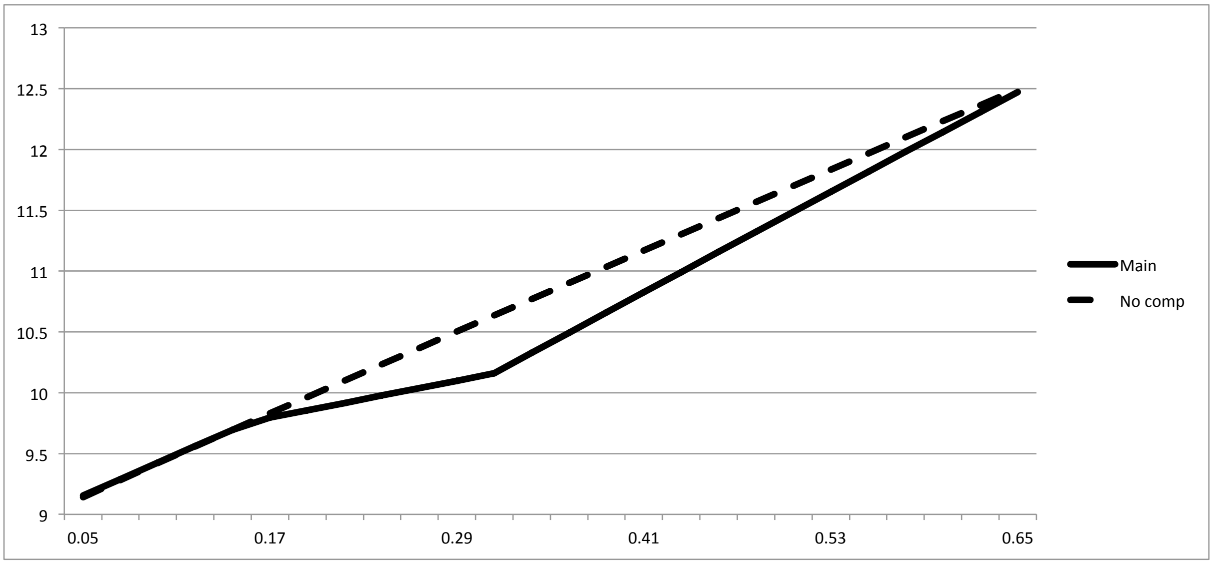

Figure 12
Social welfare as measured by NPV^A for varying levels of γ.

some low potential deals in the main model, welfare starts to lag relative to the no competition model. At the point of greatest difference, the no competition model provides approximately a 5% improvement in social welfare. As γ continues to rise, the two models again converge as the proportion of low potential firms declines.

Figure 13 performs a similar exercise but this time varies π_3^B. Here, the efficiency gap is small when π_3^B is low despite the fact that $\rho = 0$ because there is little effect of skill on exit payoffs for low potential firms. As the importance of skill rises, the efficiency gap widens as there is a greater loss due to the competitive impact of non-reputable VCs. However, the gap again narrows (and even slightly reverses) as ρ rises to one and reputable VCs do all deals that they can in both models.

5. Conclusion

In this paper we show that having a reputation for skill can make a partner less attractive in a multi-stage setting. In the context of staged financing, the fact that a reputable VC will be in high outside demand when future financing rounds are negotiated leads to a conflict between maximizing project value and maximizing reputational rents. This reduces project value through a reduction in the value of the continuation option, as well as a reduction in entrepreneurial effort due to increased

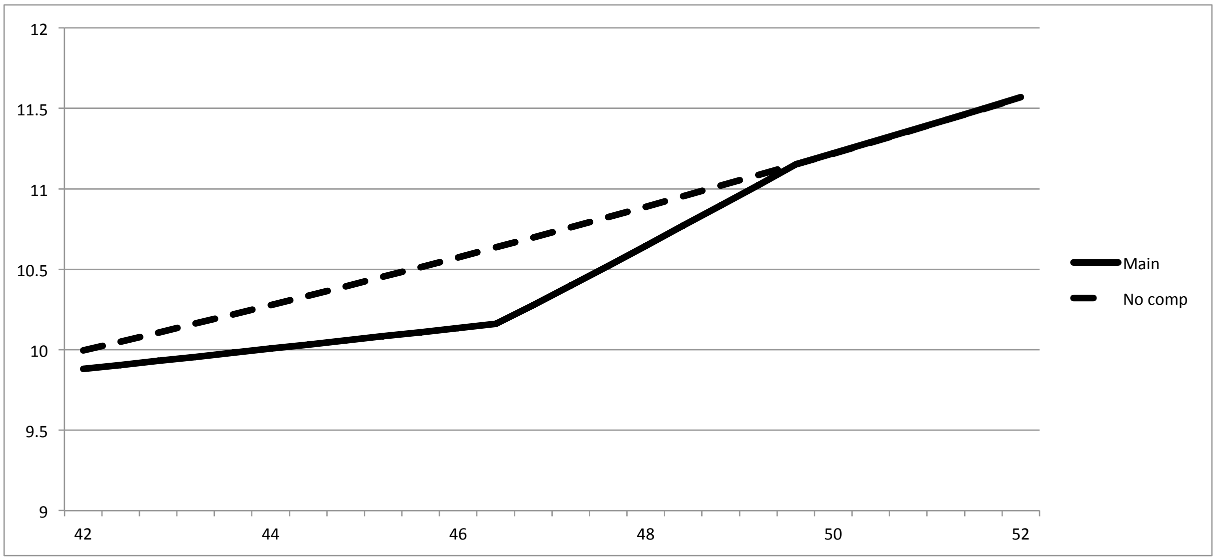

Figure 13
Social welfare as measured by NPV^A for varying levels of π_3^B.

hold-up. In addition, non-reputable VCs desire to gain reputation, and are prepared to share their expected reputational rents with entrepreneurs. As a result, more deals are done by non-reputable VCs, which amplifies the downward pressure on reputational value by increasing the supply of newly reputable VCs, and thus increasing competition for good deals.

Our results have specific implications for the value of VC reputation, the number of reputable VCs, rates of deals across different types of VCs and projects, the pricing of VC deals, the value of IPOs, and social efficiency. However, we believe that the underlying forces of our model are quite general and should apply to many other settings with multi-stage relationships where intrinsically desirable attributes are important. For example, financing relationships between borrowers and bankers who have a reputation for good monitoring, strategic alliances between younger and more established firms who have a reputation for successful product commercialization strategies, or employment relationships between researchers and universities that have a reputation for high quality research. In any such settings where long-term relationships are important, there is scope for some renegotation, and reputation improves a party's outside options, higher reputational rents will likely lead to a loss of valuable relationships and, potentially, a reduction of social welfare.

6. Appendix

Proof of Proposition 1: Follows from the text above. QED

Proof of Proposition 2: Follows from the text above. QED

Proof of Proposition 3: First consider the effect of V^R on NRS^N. From above, we know that e^N is increasing in V^R. In addition, $\underline{s}^N$ is clearly decreasing in V^R. Under the maintained assumption that we are in a parameter range where effort is inefficiently low relative to first best for the project, holding $\underline{s}^N$ constant the first line of NRS^N must increase with e^N as effort gets closer to the first best. Similarly, the second line is clearly increasing in e^N and V^R, so holding $\underline{s}^N$ constant it increases as well. Now consider separately the decrease in $\underline{s}^N$, which increases $Pr[s \geq \underline{s}^N]$ but decreases $Pr[s < \underline{s}^N]$ and $E[s|s \geq \underline{s}^N]$. Isolating the terms involving these quantities and simplifying yields $e^N\beta[Pr[s < \underline{s}^N]\pi_1 + Pr[s \geq \underline{s}^N](\beta\overline{\pi}E[s|s \geq \underline{s}^N] + \beta gE[s|s \geq \underline{s}^N]V^R(1-d) - I_2)]$. Now consider replacing $E[s|s \geq \underline{s}^N]$ with a given s. By the definition of $\underline{s}^N$, the term inside the square brackets that multiplies $Pr[s \geq \underline{s}^N]$ with this replacement is larger than π_1 for all $s \geq \underline{s}^N$. Now note that, holding $\underline{s}^N$ constant, the term in square brackets increases as V^R increases. Letting $\underline{s}^N$ fall to its new equilibrium level then effectively shifts weight toward the larger term for each s between the old and new $\underline{s}^N$, so the quantity as a whole must increase with V^R.

Next consider the effect of an increase in π_2 on NRS^N. This will clearly increase e^N and the profitability of the project itself (the first line). The second line is also clearly increasing since e^N rises and $Pr[s \geq \underline{s}^N]E[s|s \geq \underline{s}^N]$ must rise as well given the definition of $\underline{s}^N$.

The effect of π_2 on NRS^R is trivial since it does not affect any of the terms in the equation.

Now consider the effect of an increase in V^R on NRS^R. Holding $\underline{s}^R$ constant, the decrease in e^R clearly decreases project profitability (the first line). Now note that $\underline{s}^R$ is increasing in V^R. Now consider replacing $E[s|s \geq \underline{s}^R]$ with a given s. By the definition of $\underline{s}^R$, the term inside the square brackets that multiplies $Pr[s \geq \underline{s}^R]$ with this replacement is larger than π_1 for all $s \geq \underline{s}^R$. This implies that the increase in $s \geq \underline{s}^R$ is causing weight to be shifted toward the smaller term for each s between the old and new $\underline{s}^R$, so the first line must decrease overall with V^R. Now consider the second line. This can be simplified to $V^R(1-d)\beta e^R Pr[s \geq \underline{s}^R](\beta - 1)$. The derivative with respect to V^R is $\beta(\beta-1)(1-d)(e^R Pr[s \geq \underline{s}^R] + V^R\frac{\partial e^R Pr[s \geq \underline{s}^R]}{\partial V^R})$. At $V^R = 0$, this is clearly negative since

$e^R Pr[s \geq \underline{s}^R]$ is positive. The result follows from continuity.

Finally, consider the last claim in the proposition. Note from the definition of $\underline{s}^R$ that there exists a finite V^R above which $\underline{s}^R = 1$. For all V^R greater than this, the value of NRS^R is clearly negative, whereas the value of NRS^N is clearly positive. Since $NRS^R > NRS^N$ at $V^R = 0$, the result follows from continuity. QED

Proof of Proposition 4: By definition, $\underline{V}^R$ solves $NRS^N = NRS^R$. From Proposition 2, the only effect of a decrease in π_2 is to decrease NRS^N for all V^R, such that $NRS^N < NRS^R$ for all $V^R < \underline{V}^R$. The result follows. QED

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