THE JOURNAL OF FINANCE • VOL. LIX, NO. 2 • APRIL 2004

Banks versus Venture Capital: Project Evaluation, Screening, and Expropriation

MASAKO UEDA*

ABSTRACT

Why do some start-up firms raise funds from banks and others from venture capitalists? To address this question, I study a model in which the venture capitalist can evaluate the entrepreneur's project more accurately than the bank but can also threaten to steal it from the entrepreneur. Consistent with evidence regarding venture capital finance, the model implies that the characteristics of a firm financing through venture capitalists are relatively little collateral, high growth, high risk, and high profitability. The model also suggests that tighter protection of intellectual property rights encourages entrepreneurs to finance through venture capitalists.

SINCE 1980 THE U.S. VENTURE capital industry has grown dramatically. Venture capitalists are known to play a crucial role in incubating new firms by supplying them with equity capital. Banks, too, are an important source of funds for new firms. But banks seem slower than venture capitalists in meeting the financial needs of new firms. According to Ueda (2002), indicators of bank lending to small firms are constant or even fall after 1977, whereas venture capital investment is almost 100 times larger in 2001 than it was in 1977.

To understand this trend in which venture capital financing has grown significantly relative to bank financing, I develop a simple model of the trade-offs involved between financing through a bank and through a venture capitalist. The bank is less informed than either the entrepreneur or the venture capitalist, and as a result must attempt to induce self-selection for the profitable entrepreneur, make use of collateral, and demand higher payments from the profitable entrepreneur in order to break even. On the other hand, when they meet, the venture capitalist and the entrepreneur become equally informed about the project, but the venture capitalist may be able to undertake the project

*University of Wisconsin–Madison. I would like to thank Franklin Allen, Gary Gorton, Boyan Jovanovic, Matthias Kahl, Joshua Lerner, and Frank Schmid for comments at an early stage of this paper. I also thank Giacinta Cestone, Matthew Ellman, Xavier Freixas, Thomas Hellmann, Holger Mueller, Javier Suarez, Lucy White, and seminar participants at Universitat Autonoma de Barcelona (IAE), Universitet van Amsterdam, Stockholm School of Economics, University of Wisconsin–Madison, and the 2000 CEPR/Studienzentrum Gerzensee European Summer Symposium of Financial Markets for valuable discussions. Last but not least, I am grateful to Richard Green and an anonymous referee for their time and effort to improve this paper.

without the entrepreneur.[1] This threat of expropriation forces the entrepreneur to share some rents from the project with the venture capitalist.

The model generates several predictions about the determinants of the financing choice. It shows that projects financed through venture capitalists will have higher returns, higher growth, higher risk, and will be larger in size. Moreover, entrepreneurs with less collateral will raise funds from venture capitalists and not banks. Finally, a legal environment that supports capital provision through venture capitalists is one that strongly protects intellectual property rights. These predictions are broadly consistent with stylized facts on venture capital.

The model relates to two lines of literature. First, some authors have studied the trade-off between better evaluation of projects and threat of expropriation. For instance, Bhattacharya and Ritter (1983) and Yosha (1995) study the optimal degree of disclosure based on the trade-off between better screening and a threat of expropriation, as described in this paper. Anton and Yao (1994) study mechanisms to circumvent the underinvestment problem associated with misappropriation of research effort. Nonetheless, these three papers all consider only one type of financier. As a consequence, they do not explain why heterogeneous financiers, banks, and venture capitalists coexist.[2] Second, the role of venture capitalists in lessening the problem of asymmetric information has been studied by Chan (1983), who compares an economy with screening agents (venture capitalists) with one without them, and shows that introducing such agents enhances welfare. Holmstrom and Tirole (1997) develop a model of financial intermediaries that can monitor an entrepreneur's effort. Their paper shares with my paper the prediction that entrepreneurs finance through a venture capitalist if they are short of collateral. Landier (2001) also studies when capital provision through venture capitalists prevails by developing a model in which both the entrepreneur and the venture capitalist hold each other up. For reasons that I shall explain later, some of Landier's conclusions are opposite to mine. In particular, tighter protection of intellectual property rights leads to more bank financing in Landier's model, and to *less* bank financing in mine.

[1] Evidence partially supports both assumptions. First, venture capitalists typically specialize in a small group of industries (Sahlman (1990)). This specialization presumably deepens the technical knowledge about the industries in which a venture capitalist has been investing and therefore helps the venture capitalist to accurately evaluate business plans of firms in the same industries in the future. Moreover, Hellmann, Lindsey, and Puri (2003) find that bank-affiliated venture capitalists are less likely to originate venture capital deals than independent venture capitalists, hinting that banks have lower screening abilities than individual venture capitalists. Second, evidence suggests that venture-backed firms can continue the projects without their original entrepreneurs. For instance, Gorman and Sahlman (1989) argue that a venture capitalist frequently replaces an original founder as CEO. Hellmann and Puri (2002) find that venture-backed firms experience such replacement twice as much as non-venture-backed firms.

[2] One exception is Anand and Galetovic (1998), who compare financing through the venture capitalist and through the corporation. They show that when property rights are strongly protected, the entrepreneur finances first from the venture capitalist, and then from the corporation. When property rights are only weakly protected, either the corporation or the venture capitalist finances the entire life of the entrepreneur.

The paper is organized as follows. Section I sets up the model and solves for the equilibrium. Section II characterizes the equilibrium and relates the predictions of the model with the stylized facts on venture capital. Section III discusses the assumptions and the results of the model. Section IV concludes.

I. The Model

This section describes an economy in which an entrepreneur can raise funds from either a bank or a venture capitalist. All agents are risk neutral, and the risk-free interest rate is normalized to zero.

The entrepreneur is endowed with W of collateral and with a project that requires an initial cost, F. The collateral is the entrepreneur's only asset; therefore she has to finance F externally to undertake the project. If undertaken, the project yields the following:

$$\text{return} = \begin{cases} RF & \text{with probability } p \\ 0 & \text{with probability } 1-p. \end{cases} \tag{1}$$

Since the cost is F, the expected profit of the project is $(pR-1)F$. The variables F, W, and R are common knowledge, whereas p is the entrepreneur's private information.

The entrepreneur may reveal something about p by disclosing the project's content to the investor. Without disclosure, the bank and the venture capitalist know only the prior distribution of p: p may be either p_h or p_l with equal probability. I assume that

$$p_l R < 1 < p_h R, \tag{2}$$

so that the project is profitable only if $p = p_h$. Let

$$\Phi \equiv (p_h R - 1) F \tag{3}$$

be the expected profit of the profitable project.

A. *Disclosure, Assessment, and Expropriation*

A.1. Disclosure and Assessment of the Project

If the entrepreneur discloses her project to the venture capitalist, the latter learns p exactly. If the entrepreneur discloses to the bank, the bank observes only an imperfect signal, s, which is either $\bar{s}$ or $\underline{s}$. The conditional probability of the signal is $\Pr(\bar{s} \mid p_h) = \Pr(\underline{s} \mid p_l) = \alpha$, and $\Pr(\bar{s} \mid p_l) = \Pr(\underline{s} \mid p_h) = 1-\alpha$, where $\alpha \geq 0.5$. The index α measures the knowledge gap between the bank and the venture capitalist. This gap is the largest if $\alpha = 0.5$, in which case disclosing the project to the bank conveys no information about the quality of the project. On the other hand, if $\alpha = 1$, the bank learns p exactly.

A.2. Imperfect Protection of Intellectual Property Rights

Once the entrepreneur discloses the project to the venture capitalist, the latter can expropriate the entrepreneur's project, that is, undertake it on his own.[3] If he does so, the venture capitalist may have to pay a certain amount of compensation to the entrepreneur. Let $L(\Phi, q)$ be the expected amount of this compensation, where q is the parameter that measures how tightly intellectual property rights are protected. The index q is presumably large if the legal system approves a broad scope of intellectual property rights, or if the system is more efficient in prosecuting incidents of expropriation. I assume that $0 \leq L(\Phi, q) < \Phi$ and that L is nondecreasing in Φ and q. Since $L(\Phi, q) < \Phi$, the compensation payment does not fully discourage the venture capitalist from expropriating the entrepreneur's project.

B. The Sequence of Events

The entrepreneur first discloses her project to the bank, and then the entrepreneur and the bank negotiate. Only if this negotiation breaks up does the entrepreneur disclose her project to the venture capitalist, and then the entrepreneur and the venture capitalist negotiate. (This second-stage negotiation with the venture capitalist is irrelevant if the entrepreneur is unprofitable, because the venture capitalist will know $p = p_l$ and will not finance the entrepreneur.) If the entrepreneur is profitable and the negotiation between the entrepreneur and the venture capitalist breaks down, the venture capitalist may undertake the entrepreneur's project. Although I will detail the negotiation processes later, it is helpful to state now two crucial differences between the negotiation with the bank and the one with the venture capitalist. First, the venture capitalist maintains a stronger negotiating position than the bank because even if the negotiation breaks up, the venture capitalist may still benefit from the entrepreneur's project by expropriating it, whereas there is not such an option to expropriate for the bank. Second, the negotiation with the bank is subject to an information asymmetry between the entrepreneur and the bank, whereas the negotiation with the venture capitalist is not. As a consequence, the negotiation between the entrepreneur and the bank becomes more complicated than the one between the entrepreneur and the venture capitalist and therefore requires a more sophisticated analysis.

Three dates are involved as follows:

B.1. Date 0 (Negotiation with the Bank)

The entrepreneur discloses her project to the bank, and the bank observes the signal s. Because the bank's prior probability assessment is that the entrepreneur is equally likely to be either profitable or unprofitable, the posterior

[3] In practice, the venture capitalist may expropriate it by passing the project content to a firm in which the venture capitalist has already been investing and having that firm undertake the project.

probability distribution of the project's outcome given the signal is

$$\Pr(p = p_h \mid s = \bar{s}) = \frac{0.5\alpha}{0.5\alpha + 0.5(1-\alpha)} = \alpha, \tag{4}$$

$\Pr(p = p_l \mid s = \underline{s}) = \alpha$, $\Pr(p = p_l \mid s = \bar{s}) = \Pr(p = p_h \mid s = \underline{s}) = 1 - \alpha$. Unlike the bank, the entrepreneur knows exactly which type she has. Given this asymmetric information, the negotiation between the bank and the entrepreneur takes place in a manner similar to the one in the models of Rothschild and Stiglitz (1976) and Bester (1985). Their models consist of two key features. First, an uninformed party offers an incentive-compatible menu of contracts to an informed party. Second, the menu maximizes the expected payoff of a "superior type" informed party provided that the uninformed party at least receives its reservation payoff. In the current paper's context, the bank (uninformed party) offers a menu of contracts to the entrepreneur (informed party) such that the profitable entrepreneur's payoff is maximized, provided that the bank at least breaks even. Because there are only two types of entrepreneur, profitable and unprofitable, we can restrict our attention to a menu of two contracts: one contract is intended for the profitable type and the other for the unprofitable type. Each contract specifies (1) whether financing and investment take place, and (2) the amounts of transfer from the bank to the entrepreneur contingent on the realized return to the investment if financing and investment take place, and the amount of unconditional transfer from the bank to the entrepreneur otherwise.

As the offered menu must maximize the profitable type's payoff, I can hereafter restrict our attention to a menu of contracts, without loss of generality, such that financing and investment take place under a contract intended for the profitable type, and they do not occur under a contract intended for the unprofitable type.[4] Under this restriction, we can describe a menu of contracts by just three parameters $\{\pi_R, \pi_0, T\}$, where π_R and π_0 are the amounts of conditional transfer from the bank to the entrepreneur under the contract intended for the profitable type and T is the amount of unconditional transfer under the contract intended for the unprofitable type.

B.2. Date 1 (Choice of Contract)

Following the bank's offer of the menu, the entrepreneur has three options: reject the bank's offer and meet with the venture capitalist, accept the contract intended for the profitable type, or accept the contract intended for the unprofitable type. If the entrepreneur rejects the bank's offer, the bank's (net) payoff is zero. If the entrepreneur accepts the contract for the unprofitable type, the bank's payoff is $-T$, and the entrepreneur's net payoff is T and the gross payoff is $W + T$. If the entrepreneur accepts the contract for the profitable type and the

[4] If the bank would offer a different kind of menu (e.g., financing and investment occur for both types), it would not maximize the profitable type's payoff because there would be a scope for Pareto improvement by avoiding an inefficient investment in an unprofitable project.

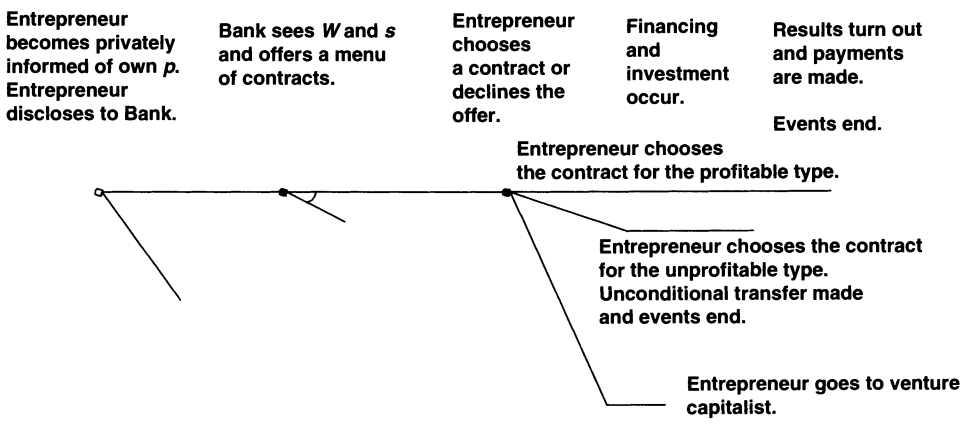

Figure 1. Date 0 and date 1.

project is successful, the bank's payoff is $RF - F - \pi_R$, and the entrepreneur's net payoff is π_R and the gross payoff is $W + \pi_R$. If the entrepreneur accepts the contract for the profitable type and the project fails, the bank's payoff is $-F - \pi_0$, and the entrepreneur's net payoff is π_0 and the gross payoff is $W + \pi_0$. I assume that the entrepreneur's gross payoff cannot be negative in any of these cases, that is, $\pi_0, \pi_R, T \geq -W$. Figure 1 summarizes the events that occur at dates 0 and 1.

B.3 Date 2 (Contracting with the Venture Capitalist)

If the entrepreneur rejects the bank's offer, the entrepreneur discloses her project idea to the venture capitalist. If the project is unprofitable, events end.[5] If it is profitable, the entrepreneur makes a take-it-or-leave-it offer of a contract to the venture capitalist.[6] Unlike the negotiation with the bank, there is no asymmetric information and no adverse selection problem. Hence, to simplify the exposition that follows, I assume that a contract takes a parsimonious form. To be concrete, a contract states that the venture capitalist finances F for the entrepreneur to undertake the project and the venture capitalist transfers π_{VC} to the entrepreneur unconditionally. If the venture capitalist declines to sign the contract, he may undertake the project on his own. If the venture capitalist undertakes the project, his expected payoff is $\Phi - L(\Phi, q)$. Otherwise his payoff is zero. If the venture capitalist accepts the contract, his payoff is $p_h RF - F - \pi_{VC} = \Phi - \pi_{VC}$. Figure 2 summarizes the sequence of events that

[5] Here, I implicitly assume an equilibrium story, in that the venture capitalist should not finance the entrepreneur if the entrepreneur is unprofitable.

[6] At first glance, this negotiation process may appear to be asymmetric to the one with the bank, in which the bank offers a menu of contracts to the entrepreneur. These specifications of negotiation processes are symmetric, however, in the sense that the entrepreneur has all the bargaining power for both processes. This is because the bank's offer must be competitive.

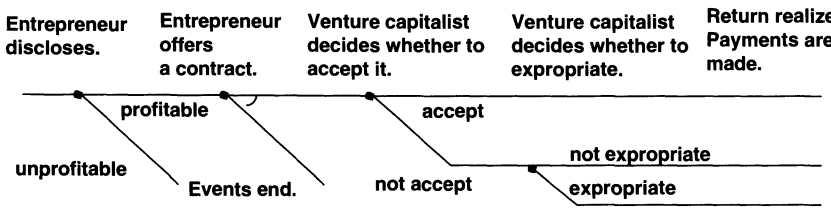

Figure 2. Date 2.

occurs at date 2. Note that this specification of the sequence does not allow the venture capitalist to duplicate the project after he has decided to accept the entrepreneur's offer and to finance the project. Depending on the characteristics of the project, in particular, the nature of the market the project aims at, the venture capitalist may still have an incentive to duplicate the project and enter the product market competition with the entrepreneur. Nonetheless, to keep the model as simple as possible, I exclude this possibility.[7]

C. Equilibrium

This section solves for and characterizes the equilibrium strategies of the entrepreneur, the bank, and the venture capitalist. The solution concept adopted is a perfect Bayesian equilibrium. Because an equilibrium must satisfy backward induction, the following exposition starts from date 2.

Before we proceed to solve for the equilibrium, first note that hereafter "the entrepreneur's expected payoff" means the entrepreneur's expected *net* payoff. Second, note that any character marked with an overbar is associated with the case in which the bank observes the good signal, and any character that is underscored is associated with the case in which the bank observes the bad signal.

C.1. Equilibrium at Date 2

If the venture capitalist declines the entrepreneur's offer of a contract, the venture capitalist's optimal strategy is to expropriate the entrepreneur's project because $L(\Phi, q) \leq \Phi$. Thus, if the venture capitalist declines the entrepreneur's offer, the venture capitalist's expected return is equal to $\Phi - L(\Phi, q)$. Consequently, to persuade the venture capitalist to accept the contract, the entrepreneur must therefore guarantee the venture capitalist a payoff of at least as much as $\Phi - L(\Phi, q)$. If the venture capitalist accepts the offer from the entrepreneur, his expected payoff is $\Phi - \pi_{VC}$. Hence, $\Phi - L(\Phi, q) \leq \Phi - \pi_{VC}$ and then $\pi_{VC} \leq L(\Phi, q)$ if the venture capitalist accepts the entrepreneur's offer. As the entrepreneur's payoff is equal to π_{VC} and she wants to increase her payoff as much as possible, the following lemma immediately follows.

[7] Ueda (1997) discusses the case in which the entrepreneur and the venture capitalist may enter the product market competition. The results would not change, however.

LEMMA 1: *Let U^{VC} be the entrepreneur's equilibrium payoff at date 2 if she is profitable; then $U^{VC} = L(\Phi, q)$.*

The entrepreneur's payoff is less than the total rent Φ since the venture capitalist captures a part of the rent to the project by threatening the entrepreneur with the possibility of expropriation.

C.2. Equilibrium at Date 1

As described in the previous section, the profitable type can get $L(\Phi, q)$ by declining the offer from the bank and financing through the venture capitalist. If the unprofitable type does this, she gets zero. Thus in equilibrium at date 1, the profitable type should accept a contract offered by the bank only if one of the contracts in the menu gives the entrepreneur at least as much as U^{VC}. The unprofitable type should accept one of the contracts only if it offers her a nonnegative expected payoff.

C.3. Equilibrium at Date 0

Given the entrepreneur's optimal strategy just described, I now solve for the optimal offer strategy of the bank. It will be solved for in two steps. First, I derive the optimal offer if there were no venture capitalist such that the entrepreneur's payoff would be zero when she declined the bank's offer. Let U^B denote the entrepreneur's payoff if she is profitable and accepts the bank's offer.[8] Second, we compare U^B with U^{VC} and see whether the bank, in equilibrium, wants to make the offer derived in the first step. If $U^B \geq U^{VC}$, the bank indeed wants to make such an offer because the profitable type optimally accepts the offer. Otherwise, the bank doesn't want to make such an offer in equilibrium, because only the unprofitable type will accept but the profitable type will not, or neither type accepts the offer.

Now I begin with deriving the benchmark payoff U^B.

C.3.1. When $\bar{s}$ Is Observed. First, I examine the optimal offer when the bank observes the good signal, $\bar{s}$. The bank chooses a menu of contracts so as to maximize the expected payoff for the profitable type

$$p_h \pi_R + (1 - p_h)\pi_0, \tag{5}$$

subject to the bank's participation constraint

$$\alpha[\Phi - \{p_h \pi_R + (1 - p_h)\pi_0\}] - (1 - \alpha)T \geq 0, \tag{6}$$

[8] This case is the same as Bester (1985). He shows that a bank in a competitive banking industry finances any positive net present value projects in equilibrium and the payoff of the entrepreneurs financed, which is U^B here, is strictly greater than zero.

the incentive compatibility condition

$$p_l \pi_R + (1 - p_l)\pi_0 \leq T, \tag{7}$$

the limited liability condition under which a negative payoff is not possible,

$$\pi_0 \geq -W, \tag{8}$$

and the unprofitable type's participation constraint

$$T \geq 0\,. \tag{9}$$

Note that the participation constraint of the unprofitable type is stated but that of the profitable one is not. This is because we know the profitable type's payoff is always positive, owing to Bester's result (see footnote 10).

LEMMA 2: *Without the venture capitalist, the expected payoff for the profitable type if* $s = \bar{s}$ *is*

$$\overline{U^B} \equiv \min\left[\Phi, \frac{\alpha p_h \Phi}{\bar{p}} + \left(\frac{p_h}{\bar{p}} - 1\right) W\right]; \tag{10}$$

the expected payoff for the unprofitable type if $s = \bar{s}$ *is*

$$\bar{T} = \max\left[0, \frac{\alpha}{\bar{p}}\{p_l \Phi - (p_h - p_l)W\}\right], \tag{11}$$

where $\bar{p} = \alpha p_h + (1 - \alpha)p_l$.

Proof of Lemma 2: Note that the bank's participation constraint (6) must be binding because otherwise there would be a scope for increasing the profitable type's payoff. Evaluating the equation (6) at equality and substituting it into the incentive compatibility condition (7) for T yields

$$\pi_R \leq \frac{\alpha\Phi - \{(1-\alpha)(1-p_l) + \alpha(1-p_h)\}\pi_0}{\bar{p}}. \tag{12}$$

Manipulating this equation gives

$$\begin{aligned}\overline{U^B} = p_h \pi_R + (1 - p_h)\pi_0 &\leq p_h \frac{\alpha\Phi - \{(1-\alpha)(1-p_l) + \alpha(1-p_h)\}\pi_0}{\bar{p}} \\ &+ (1 - p_h)\pi_0 \leq \frac{\alpha p_h \Phi}{\bar{p}} + \left(\frac{p_h}{\bar{p}} - 1\right) W.\end{aligned} \tag{13}$$

The last inequality follows the limited liability condition (8). Since $\bar{T} \geq 0$, also $\overline{U^B} \leq \Phi$ because otherwise the bank's participation constraint (6) would be

violated. Hence

$$\overline{U^B} \leq \min\left[\Phi, \frac{\alpha p_h \Phi}{\bar{p}} + \left(\frac{p_h}{\bar{p}} - 1\right) W\right]. \tag{14}$$

To demonstrate that the inequality can be replaced by equality, it suffices to show that

$$\overline{U^B} = \begin{cases} \Phi & \text{if} \quad \Phi < \dfrac{\alpha p_h \Phi}{\bar{p}} + \left(\dfrac{p_h}{\bar{p}} - 1\right) W \\ \dfrac{\alpha p_h \Phi}{\bar{p}} + \left(\dfrac{p_h}{\bar{p}} - 1\right) W & \text{otherwise.} \end{cases} \tag{15}$$

In order to show the first part of the equation (15), set $\pi_0 = -W, \pi_R = ((1 - p_h)W + \Phi)/p_h$, and $T = 0$. These values give $\overline{U^B} = \Phi$. Similarly, in order to show the second part of the equation (15), set $\pi_0 = -W, \pi_R = (\alpha\Phi + W)/\bar{p}$, and $T = \alpha(p_l \Phi - (p_h - p_l)W)/\bar{p}$. These values yield $\overline{U^B} = \alpha p_h \Phi/\bar{p} + (p_h/\bar{p} - 1)W$. Q.E.D.

C.3.2. When the Bad Signal Is Observed. The bank's problem when the bad signal is observed is identical to the one when the good signal is observed, *except* that the bank's participation constraint (6) is replaced with

$$(1 - \alpha)[\Phi - \{p_h \pi_R + (1 - p_h)\pi_0\}] - \alpha T \geq 0. \tag{16}$$

LEMMA 3: *Without the venture capitalist, the expected payoff for the profitable type if the bank observes the bad signal is*

$$\underline{U^B} = \min\left[\Phi, \frac{(1 - \alpha)p_h \Phi}{\underline{p}} + \left(\frac{p_h}{\underline{p}} - 1\right) W\right]; \tag{17}$$

the expected payoff for the unprofitable type if she has the bad signal is

$$\underline{T^B} = \max\left[0, \frac{1 - \alpha}{\underline{p}} \{p_l \Phi - (p_h - p_l)W\}\right], \tag{18}$$

where $\underline{p} = (1 - \alpha)p_h + \alpha p_l$.

Proof of Lemma 3: Similar to the proof of Lemma 2. Q.E.D.

Now I move to the second step in solving for the equilibrium and introduce the possibility that the profitable type can reject the bank's offer and finance through the venture capitalist. In this case, the bank has to take into account that the profitable type declines the offer from the bank if the contract intended for the profitable type does not guarantee the payoff of at least U^{VC}.

Note that $\overline{U^B}$ ($\underline{U^B}$) is the maximum payoff that the bank can guarantee to the entrepreneur if the bank sees the good (bad) signal and if there were no competition from the venture capitalist. Then, one can conclude that if $\overline{U^B}(\underline{U^B}) < U^{VC}$, the bank is never able to attract the profitable entrepreneur without violating the bank's participation constraint, and the profitable entrepreneur therefore finances through the venture capitalist. If the bank sees the good (bad) signal and $\overline{U^B}$ ($\underline{U^B}$) $< U^{VC}$, the bank's belief consistent with equilibrium is that only the unprofitable type will accept or neither type of entrepreneur will accept the bank's offer. In this case, the bank should make an offer such that there is no transfer between the bank and the entrepreneur in equilibrium. An example of such an offer is $\{\pi_R, \pi_0, T\} = \{-\varepsilon, -\varepsilon, -\varepsilon\}, \varepsilon < W$. On the contrary, if the bank sees the good (bad) signal and $\overline{U^B}$ ($\underline{U^B}$) $\geq U^{VC}$, the bank can, without violating its own participation constraint, attract the profitable type by offering a menu of contracts that gives the profitable entrepreneur at least as much as U^{VC}. In conclusion, the following proposition follows Lemma 2 and Lemma 3.

PROPOSITION 1: *If the entrepreneur is profitable and the bank observes the good signal, then the entrepreneur finances through the bank if and only if*

$$\overline{U^B} \equiv \min\left[\Phi, \frac{\alpha p_h \Phi}{\bar{p}} + \left(\frac{p_h}{\bar{p}} - 1\right) W\right] \geq L(\Phi, q), \tag{19}$$

and she finances through the venture capitalist otherwise. If the entrepreneur is profitable and the bank observes the bad signal, then the entrepreneur finances through the bank if and only if

$$\underline{U^B} \equiv \min\left[\Phi, \frac{(1-\alpha) p_h \Phi}{\underline{p}} + \left(\frac{p_h}{\underline{p}} - 1\right) W\right] \geq L(\Phi, q); \tag{20}$$

and she finances through the venture capitalist otherwise.

To be concrete, let $\bar{I}(W, \alpha, \Phi, q)$ be an index function such that $\bar{I} = 0$ if equation (19) is not satisfied and $\bar{I} = 1$ if equation (19) is satisfied, and let $\underline{I}(W, \alpha, \Phi, q)$ be another index function such that $\underline{I} = 0$ if equation (20) is not satisfied and $\underline{I} = 1$ if equation (20) is satisfied. In other words, the index functions $\bar{I}$ and $\underline{I}$ map the entrepreneur's signal and characteristics onto her choice of financing source. If the bank observes the good (bad) signal and the entrepreneur's characteristics give $\bar{I}(\underline{I}) = 0$, then she finances through the venture capitalist. If the bank observes the good (bad) signal and the entrepreneur's characteristics give $\bar{I}(\underline{I}) = 1$, she finances through the bank.

I conclude this section by mentioning the payoff for the unprofitable type. It is $\bar{T}(\underline{T})$ if the bank observes the good (bad) signal and the unprofitable type's characteristics give $\bar{I}(\underline{I}) = 1$. This is because the bank rationally believes that the profitable type, whose characteristics give $\bar{I}(\underline{I}) = 1$, accepts the offer and that the expected gain from lending to the profitable type can compensate the

expected loss from a non-negative transfer to the unprofitable type. Similarly, the payoff of the unprofitable type is zero if she has the good (bad) signal and her characteristics give $\bar{I}(\underline{I}) = 0$, because the bank knows that the profitable type will reject the bank's offer and go to the venture capitalist.

II. Empirical Implications

In this section, I characterize the equilibrium source of financing and discuss the empirical implications of the model.

A. *Entrepreneur with Little Collateral Goes to the Venture Capitalist*

It is commonly observed that collateral provision is an essential characteristic of bank loans, whereas it is not for venture capital financing. This observation is consistent with this model.

COROLLARY 1: *Both $\bar{I}$ and $\underline{I}$ are nondecreasing in W; that is, the entrepreneur finances through the venture capitalist if the value of her collateral is low and through the bank if the value of her collateral is high.*

Proof of Corollary 1: The proposition follows that the left-hand sides of both equation (19) and (20) are nondecreasing in W. Q.E.D.

Figure 3 visualizes Corollary 1 by plotting $\overline{U^B}$, $\underline{U^B}$, and U^{VC} as functions of W. The notation U^{VC} is constant, whereas both $\overline{U^B}$ and $\underline{U^B}$ are increasing. As a consequence, the venture capitalist is a more attractive source of financing than the bank when the collateral value is low. This is because the entrepreneur and the venture capitalist contract without asymmetric information, whereas the entrepreneur and the bank contract with asymmetric information. As the collateral value increases, the bank can recover a higher amount of the loan even if the project fails and can penalize the unprofitable type more harshly for choosing the contract meant for the profitable type. Thus, the bank can lower T and still induce the unprofitable type to choose the contract meant for her. As a consequence, the bank can also increase π_R without violating the bank's own participation constraint. If we interpret $(RF - \pi_R)/F$ as the interest rate that the bank charges to the profitable type, increasing π_R means reduction of the interest rate. Similar to the results of Bester (1985) and De Meza and Webb (1987), the model implies that the higher the collateral value, the lower the interest rate becomes. In an extreme case, if the collateral value is no less than

$$W_B \equiv \frac{p_l/p_h}{1 - p_l/p_h}\Phi, \tag{21}$$

the profitable type can capture the entire rent of the project.

When the bank observes the good signal rather than the bad signal, the entrepreneur can enjoy a lower rate of interest. This is because the good signal

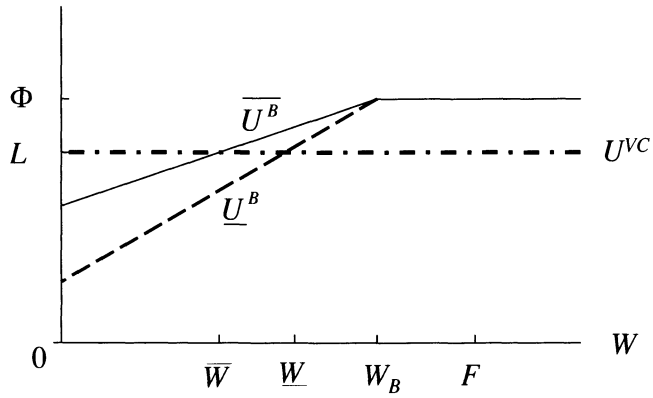

Figure 3. Comparative statics on collateral.

leads the bank to believe that the entrepreneur is unlikely to turn out to be the unprofitable type. Thus, to break even the bank can set a lower rate of interest than when the bank observes the bad signal. As a consequence, the threshold value of collateral at which the entrepreneur switches between the bank and the venture capitalist is lower if the bank observes the good signal than if the bank observes the bad signal. (In Figure 3, the threshold for the entrepreneur with whom the bank observes the good signal is denoted by $\overline{W}$, and that for the entrepreneur with whom the bank observes the bad signal is denoted by $\underline{W}$, respectively.)

B. Tight Protection of IPR Drives the Entrepreneur to the Venture Capitalist

In this model, the entrepreneur's financing decision also depends on how tightly intellectual property rights to the project are protected.

COROLLARY 2: *Both $\bar{I}$ and $\underline{I}$ are nonincreasing in q; that is, the entrepreneur finances through the venture capitalist if the intellectual property rights to her project are securely protected, and through the bank if they are not.*

Proof of Corollary 2: The proposition follows that the right-hand sides of both equations (19) and (20) are nondecreasing in q. Q.E.D.

When the entrepreneur holds secure property rights to her project, the venture capitalist's threat to expropriate it becomes weak because a potential high penalty discourages the venture capitalist from expropriating it. In the extreme case that $L(\Phi, q)$ is as much as Φ, the venture capitalist's threat is not effective at all.

This proposition suggests that the legal environment that tightly protects intellectual property rights may stimulate development of venture capital markets by encouraging entrepreneurs to switch their financing source from banks to venture capitalists. There are a couple of observations that conform with this prediction. First, the frequency of venture capital financing relative to

bank financing is higher in the United States than in Europe, and also intellectual property rights are more tightly protected in the United States than in Europe. For instance, the United States patent office began to approve software patents and business-model patents prior to patent offices in any other country, suggesting that the United States has been more committed to protecting intellectual property rights than other countries (Merges (1992)). Hence, this pro-patent policy in the United States may be one reason why the United States has a bigger venture capital market than any other countries. Second, the timing of first business model patents interestingly coincides with the start of the explosive growth of the U.S. venture capital industry in the late 1990s. This coincidence may have to do with the role of business model patents in protecting entrepreneurs from venture capitalists' expropriation and encouraging entrepreneurs to finance through venture capitalists.[9]

Landier (2001) also studies the relationship between the protection of intellectual property rights and financing choice and concludes that protecting intellectual property rights *prompts the entrepreneur to finance through banks* rather than venture capitalists. The reason why Landier's conclusion is opposite to mine is that in his model, patents are means to protect investors (rather than entrepreneurs) from expropriation by entrepreneurs. When intellectual property rights are tightly protected and the threat of expropriation is therefore lower, investors monitor the entrepreneurs less intensively and as a consequence resemble banks rather than venture capitalists.

C. *Large Project Financed by the Venture Capitalist*

Which funding source makes the larger investment: banks or venture capitalists? Kaplan and Stromberg (2003) find that venture capitalists invest a median of $4.5 million in their portfolio companies at each stage. This seems significantly larger than the amount that banks lend to start-up firms. As a rough comparison, since 1996 the United States Small Business Administration has defined a loan of less than $1 million as a proxy for small business lending. Considering that start-up firms are small as well, these facts suggest that a venture capitalist makes a bigger investment in a single company than a bank does. In the model, an amount of investment into a single firm is F. Does the model also predict that the entrepreneur finances through the venture capitalist if F is large?

The model as it is does not provide a clear answer to this question. Note that $\bar{I}$ and $\underline{I}$ are not always nonincreasing in F because both sides of equations (19) and

[9] In the late 1990s, the United States patent office started to grant patents to business models. As a consequence, 1999 saw a heated debate on the patenting of business models. For instance, Moschella (1999) discusses "the recent spate of Internet patent lawsuits, questioning whether we can really take seriously Amazon.com's claim that its 1-Click express checkout capability is a unique and patent-worthy invention that Barnesandnoble.com should not be allowed to imitate." Nonetheless, in two landmark cases, the United States Court of Appeals for the Federal Circuit made clear that methods of doing business were not beyond the purview of patent protection (Brown (2000)).

(20) are nondecreasing in F. Roughly speaking, if F is larger, expected payoff for the profitable entrepreneur is higher regardless of whether she finances through the bank or the venture capitalist. Thus, the effect of F on the financing choice crucially depends on the shape of the function $L(\Phi, q)$, in which Φ depends on F.

From now on, I assume that $L(\Phi, q) = q\Phi$. The justification for this assumption is as follows. In intellectual property rights cases where the defendant is found guilty of infringement, the defendant is typically ordered to compensate the plaintiff for the value of the property infringed upon, which in this model is equal to Φ. The chance that judges recognize the infringement depends on how tightly intellectual property rights are protected, which is expressed by q. Therefore, the expected penalty that the venture capitalist would have to pay if he were to copy the entrepreneur's project is equal to $q\Phi$. Under this assumption, since $\Phi \equiv (p_h R - 1)F$, we can rewrite this as $L(\Phi, q) = q(p_h R - 1)F$. I continue to assume that $L < \Phi$, which is equivalent to $q < 1$.

Noting that now $U^{VC} = q(p_h R - 1)F$, the model implies the following.

COROLLARY 3. *Suppose $L(\Phi, q) = q(p_h R - 1)F$. Then, both $\bar{I}$ and $\underline{I}$ are nonincreasing in F; that is, the entrepreneur finances through the venture capitalist if the entrepreneur's project is large and through the bank if it is small.*

Proof of Corollary 3: Take $\overline{U^B}$, $\underline{U^B}$, and U^{VC} as functions of F. The proof consists of two steps. In the first step, we see that both $\overline{U^B}$ and $\underline{U^B}$ are strictly greater than U^{VC} if F is small enough, and in the second step, we see that U^{VC} crosses each $\overline{U^B}$ and $\underline{U^B}$ at most once. Let

$$F^* = \frac{p_h/p_l - 1}{p_h R - 1} W, \tag{22}$$

then if $F \leq F^*$, $\overline{U^B} = \underline{U^B} = \Phi$ according to Lemma 2 and Lemma 3. Thus, the entrepreneur can appropriate the entire rent to the project by financing through the bank. Because $U^{VC} < \Phi$, if $F \leq F^*$, both $\bar{I}$ and $\underline{I}$ are equal to one (i.e., the entrepreneur finances through the bank).

Now suppose that $F > F^*$; then

$$\overline{U^B} \equiv \frac{\alpha p_h \Phi}{\bar{p}} + \left(\frac{p_h}{\bar{p}} - 1\right) W, \tag{23}$$

and

$$\underline{U^B} \equiv \frac{(1-\alpha) p_h \Phi}{\hat{p}} + \left(\frac{p_h}{\hat{p}} - 1\right) W \tag{24}$$

according to Lemma 2 and Lemma 3. Since both $\overline{U^B}$ and U^{VC} are linear in F, there is at most one value of F such that $U^{VC} = \overline{U^B}$. Similarly there is at most one value of F such that $U^{VC} = \underline{U^B}$. Together with the observation that $\overline{U^B} = \underline{U^B} > U^{VC}$ when $F \leq F^*$, the corollary follows. Q.E.D.

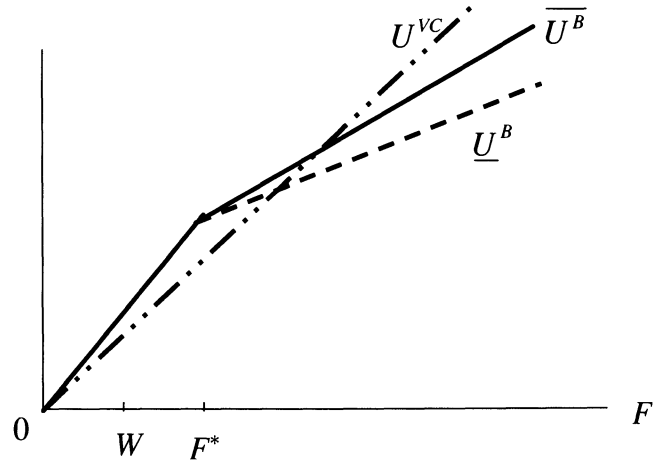

Figure 4. Comparative statics on project size.

Figure 4 illustrates how the entrepreneur's payoff changes in F. If $F \leq W$, the entrepreneur can finance the project by issuing a risk-free debt. If $W < F \leq F^*$, the entrepreneur can still appropriate all returns to the project by financing through the bank, since the asymmetric information problem is completely circumvented through the bank's threat to seize the entrepreneur's collateral. If $F > F^*$, the asymmetric information becomes costly, such that the bank has to bribe the unprofitable entrepreneur by a positive transfer T in order to screen profitable projects from unprofitable ones. This also costs the profitable entrepreneur because the bank demands a high rate of interest to break even. For this reason, both $\overline{U^B}$ and $\underline{U^B}$ are truncated at $F = F^*$. On the other hand, in the absence of the asymmetric information problem, U^{VC} is linear in F everywhere and therefore strictly smaller than $\overline{U^B}$ and $\underline{U^B}$, if F is small enough.

Interpreting F/W as the growth rate of the firm, Corollary 1 and Corollary 3 together predict that high-growth projects should be financed through venture capital. Consistent with this prediction, Hellmann and Puri (2000) find that in Silicon Valley, venture-backed firms grow faster than non-venture-backed counterparts.

D. High-Rate-of-Return Project Goes to the Venture Capitalist

Maintaining the assumption $L = q\Phi \equiv q(p_h R - 1)F$, the model also implies that the entrepreneur tends to finance through the venture capitalist if the rate of return to the project is high.

COROLLARY 4: *Suppose* $L(\Phi, q) = q(p_h R - 1)F$. *Then, both* $\bar{I}$ *and* $\underline{I}$ *are nonincreasing in* R; *that is, the entrepreneur finances through the venture capitalist if the entrepreneur's project has a high rate of return and through the bank if it has a low rate of return.*

Proof of Corollary 4: Similar to the proof of Corollary 3.

Note that since the expected profit $(p_hR - 1)F$ is increasing in both R and F, Corollary 3 and Corollary 4 also suggest that the entrepreneur with a high-profitability project tends to go to the venture capitalist.

E. High-Risk Project Financed by the Venture Capitalist

Another stylized fact is that venture-capital-backed firms are risky. For instance, Huntsman and Hoban (1980) review 110 investments made by three venture capital organizations between 1960 and 1975. They find that 17 percent of the sample generated a complete loss (−100 percent) for the investors. The median return was only 4 percent, and only one-quarter of the sample exceeded the average return of the portfolio. These results appear to have changed little as the venture capital industry has matured (Horsley (1997)). The model also predicts that high-risk projects are financed through the venture capitalist rather than the bank.

The variance of the return is

$$p_h(R - p_hR)^2 + (1 - p_h)(-p_hR)^2 = \frac{1 - p_h}{p_h}(p_hR)^2. \tag{25}$$

Hence, given the mean return p_hR constant, the lower the p_h, the riskier the project.

COROLLARY 5: *Suppose $L(\Phi, q) = q(p_hR - 1)F$. Then, given p_hR constant, both $\bar{I}$ and $\underline{I}$ are nonincreasing in p_h; that is, the bank finances the safe project and the venture capitalist finances the risky project.*

Proof of Corollary 5: Similar to that of Corollary 3.

The intuition behind this proposition is as follows. As p_h decreases, the difference between a profitable entrepreneur and an unprofitable one becomes smaller. As a consequence, it gets more difficult and costly to distinguish the two types by the choice of contracts they are offered by the bank. As a consequence, financing through the bank becomes expensive, and a marginal entrepreneur switches from the bank to the venture capitalist.

F. High-tech Entrepreneur Finances through the Venture Capitalist?

It is a stylized fact that high-tech firms often raise funds through venture capitalists. Is the model consistent with this fact? The variable in this model that best captures "high-techness" is α because it measures the knowledge gap between the bank and the venture capitalist. Understanding business plans of high-tech firms requires technological expertise. As a consequence, venture capitalists presumably have a strong advantage relative to commercial banks in evaluating these kinds of firms and therefore α is presumably bigger if the entrepreneur's project is high-tech. Then, how does α affect the choice of the

financing source? The answer to this question is ambiguous, however, because two opposite effects arise if α changes. Let's take the case in which α decreases. If the bank sees the good signal, this is not as good a sign as before, and therefore the bank offers a more conservative contract to the profitable entrepreneur in order to break even. If the bank sees the bad signal, this is not as bad a sign as before, and therefore the bank can offer better contract terms to the profitable type than before. In short, $\overline{U^B}$ is increasing in α while $\underline{U^B}$ is decreasing in α. The first effect drives the entrepreneur to get away from the bank and to finance through the venture capitalist, and the second effect is the reverse. As a consequence, the impact of α on the financing source is not clear, and the model does not necessarily imply that high-tech firms tend to finance through the venture capitalist.

III. Discussion

In this section I discuss the assumptions and the results of the model.

A. *Can Contracts Prevent Expropriation?*

The preceding discussion on the relation between protection of intellectual property rights and the choice of financing source assumes that the legal system is not complete in protecting intellectual property rights. Can a contractual arrangement, rather than the legal system, circumvent expropriation of intellectual property rights? Putting this question into the context of the current paper, can the entrepreneur prevent the venture capitalist from expropriating the entrepreneur's project by forcing the venture capitalist to sign a contract such that he must pay an enormous penalty for expropriation? I do not believe so, for the same reason that it is difficult to sell information.

There are two points at which the entrepreneur can ask the venture capitalist to sign such a contract. One is *after* the entrepreneur reveals the content of the project to the venture capitalist. At this point, the venture capitalist already knows the content of the project and can possibly use this knowledge without buying it from the entrepreneur. Thus the venture capitalist does not have any incentives to sign such a contract. The other timing is *before* the entrepreneur reveals the content of the project to the venture capitalist. Would the venture capitalist sign such a contract in order to persuade the entrepreneur to disclose the content of the project? This also seems unlikely because, at this point, the venture capitalist has not yet learned the content of the project and hence signing such a contract involves a risk; the entrepreneur may be demanding that the venture capitalist sign such a contract for reasons other than financing. In particular, the entrepreneur might have approached the venture capitalist knowing that the venture capitalist is about to invest in another company, the project of which is very similar to the one of the entrepreneur. In this way, if the venture capitalist signs such a contract, the entrepreneur can easily blackmail the venture capitalist with the threat of a legal suit.

B. Why Does the Bank not Consult the Venture Capitalist?

The bank may be able to avoid making mistakes in assessing the project by hiring the venture capitalist just to evaluate the entrepreneur's project. In this case, however, the entrepreneur would not want to disclose the project to the bank, because the bank would be able to require a high rate of return by threatening the entrepreneur with the possibility that the venture capitalist may copy the project. The inability to understand the entrepreneur's project accurately may be the bank's advantage over the venture capitalist since the bank can commit to not imitating the entrepreneur's idea.

C. In Reality, Does a Bank Offer a Menu of Contracts?

I assumed that the bank offers a menu of contracts to induce self-selection by the entrepreneur. How does the bank do this in practice? Although banks (unlike insurance companies) do not seem to offer a menu of contracts explicitly, other elaborate financial arrangements may facilitate the self-selection. For instance, commercial banks sometimes offer favorable terms for large deposits. This may work as a means to screen unprofitable entrepreneurs since they know that such deposits will yield a higher return than undertaking their own projects. The staging of finance may also function as a screening device: the bank may initially lend a part of the total funds required at a low interest rate and later lend the rest of the funds at a high interest rate. The profitable entrepreneur will be confident enough that he or she will accomplish the project to borrow the full amount required, whereas the unprofitable entrepreneur will not want to borrow at the later stage.

D. Timing

In this paper, I assume that the entrepreneur first negotiates with the bank, and only if their bargaining fails will the entrepreneur negotiate with the venture capitalist. What if the entrepreneur can choose either the bank or the venture capitalist to negotiate with first? The model, as it is, then has multiple equilibria. In addition to the equilibrium financing source under the original timing assumption, there are equilibria in which the venture capitalist finances richer types of entrepreneur than those under the original timing assumption. This is because the bank's beliefs are self-enforcing. If the bank believes that the profitable entrepreneur meets the venture capitalist first and finances through the venture capitalist, then only the unprofitable type comes to negotiate with the bank. As a consequence, the bank does not offer an attractive term of contracts to such an entrepreneur, and then this belief induces the profitable type to negotiate with the venture capitalist first and to finance through him.

Nonetheless, these kinds of equilibria are not robust because they are supported by a *weakly dominated strategy* of the entrepreneur, who finances through the bank under the original timing assumption. Note that disclosing the project to the bank does not invite a threat of expropriation and is costless.

Hence, if the entrepreneur negotiates with the bank first, she can get at least the same payoff that she would get if she met the venture capitalist first. When the bank is following the equilibrium strategy under the original timing, the entrepreneur can get a higher payoff by negotiating with the bank first. Hence, negotiating with the venture capitalist first is weakly dominated by negotiating with the bank first. Therefore, the original timing assumption is plausible and the model stands up to allowing the entrepreneur to choose the sequence of the negotiation.

IV. Conclusion

In this paper, I studied the choice of financing source when venture capitalists can assess an entrepreneur's idea better than banks can, but are also in a position to expropriate the idea. This assessment advantage makes financing through the venture capitalist attractive, but it entails the cost of revealing proprietary information and inviting the threat of expropriation by the venture capitalist. When an entrepreneur finances through a bank, she has to incur a signaling cost due to the bank's poorer assessment skill but can avoid the threat of expropriation. The choice between the bank and the venture capitalist depends on two elements: (1) the severity of the asymmetric information problem between the entrepreneur and the bank, and (2) how strongly intellectual property rights are protected. Low collateral value, high growth, high return, and high risk of the project all raise the cost of the asymmetric information and thereby drive the entrepreneur to finance through the venture capitalist. Stronger protection of intellectual property rights weakens the threat that the venture capitalist may expropriate the entrepreneur's project, and thereby encourages the entrepreneur to finance through the venture capitalist. These implications of the model are broadly consistent with the stylized feature of venture-backed firms, and geographical and historical patterns of the venture capital industry.

REFERENCES

Anand, Bharat, and Alexander Galetovic, 1998, Weak property rights and hold-up in R & D, *Journal of Economics and Management Strategy* 9, 615–642.

Anton, James J., and Denis A. Yao, 1994, Expropriation and inventions: Appropriable rents in the absence of property rights, *American Economic Review* 84, 190–209.

Bester, Helmut, 1985, Screening vs. rationing in credit markets with imperfect information, *American Economic Review* 75, 850–855.

Bhattacharya, Sudipto, and Jay Ritter, 1983, Innovation and communication: Signaling with partial disclosure, *Review of Economic Studies* 50, 331–346.

Brown, Marc E., 2000, Internet patents: A virtual land grab, *Electronic Business* 26, 26.

Chan, Yuk-Shee, 1983, On the positive role of financial intermediation in allocations of venture capital in a market with imperfect information, *Journal of Finance* 38, 1543–1561.

De Meza, David, and David Webb, 1987, Too much investment: A problem of asymmetric information, *Quarterly Journal of Economics* 102, 281–292.

Gorman, Michael, and William Sahlman, 1989, What do venture capitalists do? *Journal of Business Venturing* 4, 231–248.

Hellmann, Thomas, Laura Lindsey, and Manju Puri, 2003, Building relationships early: Banks in venture capital, Working paper, Stanford University.

Hellmann, Thomas, and Manju Puri, 2000, The interaction between product market and financing strategy: The role of venture capital, *Review of Financial Studies* 13, 959–984.

Hellmann, Thomas, and Manju Puri, 2002, Venture capital and the professionalization of start-up firms: Empirical evidence, *Journal of Finance* 57, 169–197.

Holmstrom, Bengt, and Jean Tirole, 1997, Financial intermediation, loanable funds, and the real sector, *Quarterly Journal of Economics* 112, 663–691.

Horsley, Phillip, 1997, *Trends in Private Equity* (Horsley/Bridge, San Francisco).

Huntsman, Blaine, and James P. Hoban Jr., 1980, Investment in new enterprise: Some empirical observations on risk, return and market structure, *Financial Management* 9, 44–51.

Kaplan, Steve, and Per Stromberg, 2002, Financial contracting meets the real world: An empirical study of venture capital contracts, *Review of Economic Studies* 90, 281–315.

Landier, Augustin, 2001, Start-up financing: Banks vs. venture capital, Working paper, MIT.

Merges, Robert P., 1992, *Patent Law and Policy* (Michie Company, Charlottesville).

Moschella, David, 1999, United States patent law puts the Web economy at risk, *Computerworld* 33, 31.

Rothschild, Michael, and Joseph Stiglitz, 1976, Equilibrium in competitive insurance markets: An essay on the economics of imperfect information, *Quarterly Journal of Economics* 82, 629–649.

Sahlman, William A., 1990, The structure and governance of venture-capital organizations, *Journal of Financial Economics* 27, 473–521.

Ueda, Masako, 2002, Banks versus venture capital, CEPR Discussion paper 3411.

Ueda, Masako, 1997, Expertise and finance: Mergers motivated by technological change, UPF Working paper.

Yosha, Oved, 1995, Information disclosure costs and the choice of financing source, *Journal of Financial Intermediation* 4, 3–20.