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BANKS VERSUS VENTURE CAPITAL

Masako Ueda

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Masako Ueda, University of Wisconsin, Madison and CEPR

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Centre for Economic Policy Research
90–98 Goswell Rd, London EC1V 7RR, UK
Tel: (44 20) 7878 2900, Fax: (44 20) 7878 2999
Email: cepr@cepr.org, Website: www.cepr.org

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ABSTRACT

Banks versus Venture Capital*

Why do some start-up firms raise funds from banks and others from venture capitalists? To answer 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. The implications of the model are consistent with empirical regularities of start-up financing. The model implies that the characteristics of a firm financing from venture capitalists are low collateral, high growth, high risk, and high profitability. The model also suggests that tighter protection of intellectual property rights has contributed to the recent dramatic growth of the US venture capital industry.

JEL Classification: G24
Keywords: bank, intellectual property rights and venture capital

Masako Ueda
School of Business
University of Wisconsin-Madison
975 Univ. Ave
Madison WI 53706
USA
Tel: (60 8) 262 3656
Fax: (60 8) 265 4195
Email: mueda@bus.wisc.edu

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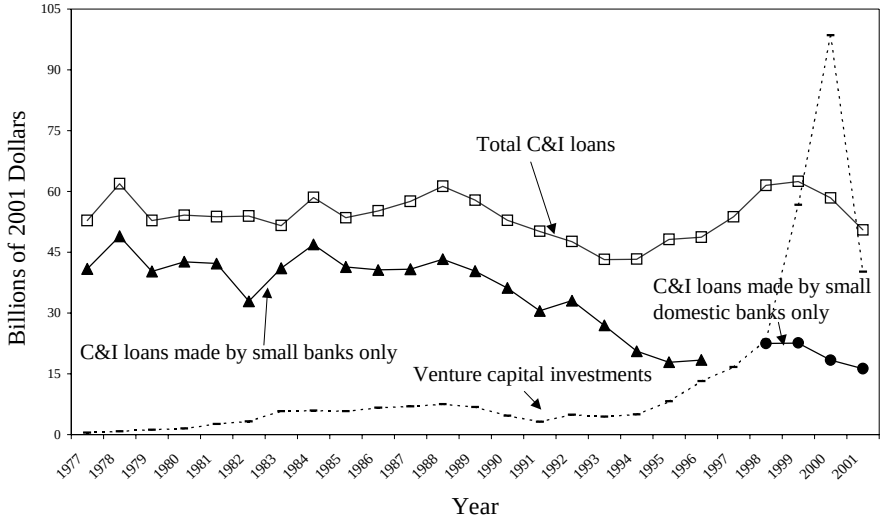
Figure 1: Small Business Financing, 1977-2001
Venture Capital Investments, and Commercial and Industrial (C&I) Loans of Less than $1 million



Data Sources: The loan data come from Survey of Terms of Bank Lending (1977-1997) and Survey of Terms of Business Lending (1997-2001) by the Federal Reserve System. The venture capital data come from National Venture Capital Association (NVCA). Total C&I loans are the sum of commercial and industrial loans less than $1 million made by a sample of commercial banks during the first full business week in the mid-month of each quarter. Venture capital investment is the sum of investments made by NVCA member venture capitalists. The amount of loans and the amount of venture capital investment are not directly comparable here because the loan data is collected and aggregated over only four weeks whereas the venture capital investment data is collected and aggregated over an entire year.

1 Introduction

Since 1980 the U.S. venture capital industry has grown dramatically. Venture capitalists are known to play a crucial role in incubating new and small firms by supplying them with equity capital. Another important source of funds for new and small firms are banks, but these seem rather slow in meeting the financial needs of small and new firms. Figure 1 compares how these two sources of funds for small businesses have recently developed in the United States. The solid lines, which are proxies for bank lending activities to small businesses, have remained almost flat or sloped down since 1977 whereas the amount of

venture capital investment in 2001 is almost as 100 times much as that in 1977. [1][2]

This paper asks why venture capital became so important as compared to banks. To answer this question, I develop a simple model of the trade-offs involved between financing through a bank and through a venture capitalist (VC). The cost to finance from the bank is asymmetric information and the cost to finance from VC is a threat of expropriation. The bank is less informed than the entrepreneur about the project, and this asymmetric information prevents the entrepreneur from fully capturing the project's rent. VC and the entrepreneur, once they meet, become equally informed about the project, but VC can possibly undertake the project without the entrepreneur.[3] This threat of expropriation forces the entrepreneur to share some rents to the project with VC. The model generates a variety of predictions about the determinants of the financing choice. The model shows that the project financed by VC is characterized by high return, high risk and large size. The entrepreneur who raises funds from VC owns low collateral. The legal environment that nurtures VC is one that strongly protects intellectual property rights.[4] If we interpret the ratio of the project size to the entrepreneur's collateral as the growth rate of the firm, the model predicts that the firm financed by VC grows fast. These predictions are mostly

[1] US Small Business Administration defines loans of less than $1 million as a proxy for small business lending.

[2] For comparison with venture capital investment, it would be more accurate to use the sum of lending amounts to *small business* rather than the sum of small-size loans, as large firms may also obtain small-size loans. Nonetheless, the data on lending to small business are collected infrequently. (For instance, see National Survey of Small Business Finance by Board of Governors, Federal Reserve System.) Based on this survey, Berger and Udell (1998) report that in 1993, 36.27% of external funds for small businesses originated from commercial banks, 3.57% from venture capital, and 15.3% from other financial institutions such as finance companies.

[3] Justifications for both assumptions are well documented. First, VC companies typically specialize in a small group of industries (Sahlman 1990). This specialization presumably deepens the technical knowledge about the industries in which VC has been investing and therefore helps VC to screen business plans in the future. Second, evidence shows that VC-backed firms can continue the projects without the original entrepreneur. For instance, Gorman and Sahlman (1989) argue that venture capitalists frequently replace the original founders as CEO. Hellmann and Puri (1999) find that venture-backed firms experience such replacement twice as much as non-venture-backed firms.

[4] On the contrary, Landier (2001) predicts that tighter protection of intellectual property is associated with banks. This is because he asssumes that an entrepreneur instead of a financier can expropriate returns to venture capital investments.

consistent with stylized facts on venture capital.

This paper is related to two types of literature. First, a few 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 threat of expropriation as described in this paper. Anton and Yao (1994) study the mechanism to circumvent the underinvestment problem associated with misappropriation of research efforts. Nonetheless, these three papers all consider only one type of financier. As a consequence, they do not ask why heterogeneous financiers, bank and VC, exist.[5] Second, the role of VC in lessening the problem of asymmetric information has been studied since Chan (1983), who compares the economy with screening agents (VC) and the one without, and shows that introducing such agents enhances welfare. Holmstrom and Tirole (1997) and Dessi (1999) develop a model of financial intermediaries that can monitor how much an entrepreneur makes efforts. These two papers share with this present paper the prediction that entrepreneurs finance from VC if they are running short of collateral. What distinguishes this paper from the existing works is richness of the model's predictions. Unlike the existing papers, this paper can organize numerous stylized facts and new predictions about banks versus VC into a simple setup.

The rest of the paper is organized as follows. Section 2 sets up the model and solves for the equilibrium. Section 3 characterizes equilibrium and relates the predictions of the model with the stylized facts on venture capital. Section 4 discusses the assumptions and the results of the model. Section 5 concludes.

[5] One exception is Anand and Galetovic (1998), who compares financing by the VC and by the corporation. They show that when property rights are strong, the entrepreneur finances from the VC at first and then from the corporation. When property rights are weak, either the corporation or the VC finances the entire life of the entrepreneur.

2 The Model

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

E is endowed with the amount of collateral W and with a project that requires the amount of investment F as the outlay. The collateral W is the only assets of E; therefore E has to finance F externally to undertake the project. If the project is undertaken, it returns RF with probability p and zero with probability $1-p$. Thus, expected profit of the project is equal to $(pR-1)F$. The variables F, W, and R are common knowledge, whereas p is E's private information. Nonetheless, as described next, E may lessen this asymmetric information about p by disclosing the project's content. Without disclosure, B and VC know only the prior distribution of p: p may be either p_h or p_l with equal probability. I assume that

$$p_h R > 1 > p_l R;$$

that is, the project is profitable if $p = p_h$, and not profitable otherwise. In the following paragraph, I refer to a project whose p equals p_h (p_l) as the profitable (unprofitable) project, and E who holds the profitable (unprofitable) project as profitable (unprofitable) E. As simplified notation, let Φ be equal to $(p_h R-1)F$, which is the expected profit of the profitable project.

2.1 Disclosure, Assessment, and Expropriation

Disclosure and Assessing the Project. If E discloses her project to VC, E and VC become equally informed about p. If E discloses to B, the asymmetric information between E and B may remain; B observes a signal, s, which is correlated with p in the following manner. This signal s is either $\overline{s}$ or $\underline{s}$. The conditional probability of the signal is $\text{prob}(\overline{s}|p_h) = \text{prob}(\underline{s}|p_l) = \alpha$, and $(\overline{s}|p_l) = \text{prob}(\underline{s}|p_h) = 1-\alpha$, where $\alpha \geq .5$. The index α measures

the knowledge gap between B and VC. This gap is the largest if $\alpha = .5$, in which case disclosing the project to B conveys no information about the quality of the project. On the other hand, if $\alpha = 1$, B has the same ability to identify the quality as VC does. In knowledge-based industries, α is presumably low because understanding the details of the project requires advanced technological knowledge.

Imperfect Protection of Intellectual Property Rights. Once E discloses the project to VC, VC can expropriate E's project, that is, undertake it on his own. In practice, VC may expropriate it by passing the project content to a firm in which VC has been already investing and having that firm to undertake the project. If this expropriation occurs, VC may have to pay a certain amount of compensation to E. The expected amount of this compensation may depend on both the project's profitability Φ and the parameter q, which measures how tightly intellectual property rights are protected. To be concrete, let $L = L(\Phi, q)$ be the expected compensation that VC has to pay to E if VC expropriates E's project. I assume that L is non-negative, less than and non decreasing in both entries. The reason for assuming that L is non-decreasing in Φ is that the higher the value of the project, the more damage E incurs from expropriation by VC. And E can possibly demand ahigher amount of compensation from VC. 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.

2.2 Sequence of Events

E first discloses her project to B, and then E and B negotiate. Only if this negotiation breaks up, E discloses her project to VC, and then E and VC negotiate. (This second-stage negotiation with VC is irrelevant if E is unprofitable, because VC will know $p = p_l$ and will not finance E.) If E is profitable and the negotiation between E and VC breaks down, VC may undertake E's project. Although I will detail the negotiation processes later, it

is helpful to state now two crucial differences between the negotiation with B and the one with VC. First, VC maintains a stronger negotiating position than B because declining to finance allows VC to undertake the project instead of E. Second, the negotiation with B takes place between asymmetrically informed parties E and B, whereas the negotiation with VC takes place between symmetrically informed parties, E and VC. As a consequence, the negotiation between E and B becomes more complicated than the one between E and VC and requires a more sophisticated analysis.

Three dates are involved:

Date 0 (negotiation with B): E discloses her project to B, and B observes the signal s. Because B's prior probability assessment is that E is equally likely to be either profitable or unprofitable, the posterior probability with which $p = p$ is

$$prob(p = p_h | s = \overline{s}) = \frac{.5\alpha}{.5\alpha + .5(1-\alpha)} = \alpha \ ,$$

$prob(p = p_l | s = \underline{s}) = \alpha$, $prob(p = p_l | s = \overline{s}) = prob(p = p_h | s = b) = 1 - \alpha$. Unlike B, E knows exactly which type she has. Given this asymmetric information, the negotiation between B and E takes place in a similar manner to the one in the models of Rothschild and Stiglitz (1976) and Bester (1985). Their models consist of two key features. First, a uninformed party offers an incentive-compatible menu of contracts to an informed party. Second, the menu maximizes the expected payoff of "good type" informed party subject to that the uninformed party at least receives its reservation payoff. In the current paper's context, B (uninformed party) offers a menu of contracts to E (informed party). Because there are only two types of E, 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 takes place, and (2) transfer amounts from B to E contingent on the realized return to the investment if financing and investment take place, and unconditional transfer from B to E otherwise.

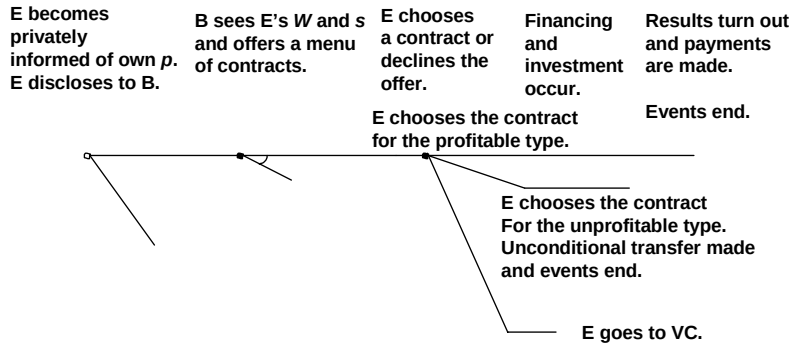


Figure 1: t = 0,1

Without loss of generality, I focus on menus of contract 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. This is not restrictive because if B offers a different kind of menu (e.g. financing and investment occur for both types), it does not necessarily maximize E's payoff. Under this restriction, we can describe a menu of contract by just three parameters $\{\pi_R, \pi_0, T\}$, where π_R and π_0 are the transfer from B to E under the contract intended for the profitable type and T is unconditional transfer under the contract intended for the unprofitable type.

*Date 1 (*E*'s Choice of a Contract)*: Facing B's offer of the menu, E has three options: reject B's offer and meet with VC, accept the contract intended for the profitable type, or accept the contract intended for the unprofitable type. If E rejects B's offer, B's (net) payoff is zero. If E accepts the contract for the unprofitable type, B's payoff is $-T$, and E's net payoff is T and gross payoff is $W + T$. If E accepts the contract for the profitable type and the project is successful, B's payoff is $RF - F - \pi_R$, and E's net payoff is π_R and gross payoff is $W + \pi_R$. If E accepts the contract for the profitable type and the project fails, B's payoff is $-F - \pi_0$, and E's net payoff is π_0 and gross payoff is $W + \pi_0$. I assume that E's gross payoff cannot be negative in any case, that is, $\pi_0, \pi_R, T + W \geq 0$. Figure 2 summarizes the events that occur at dates 1 and 2.

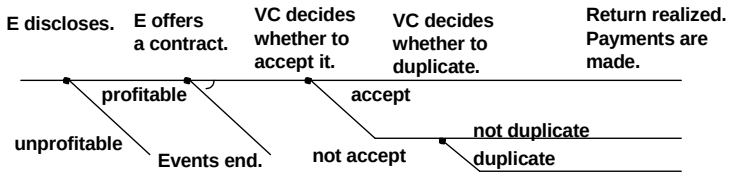


Figure 2: t = 2

Date 2 (Contracting with VC): If E rejects B's offer, E discloses her idea to VC. If she is unprofitable, events end.[6] If she is profitable, E makes a take-it-or-leave-it offer of a contract to VC.[7] Unlike the negotiation with B, 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 VC finances F for E to undertake the project and VC transfers π_{VC} to E unconditionally. If VC declines to sign the contract, he may undertake the project on his own. If VC undertakes the project, his expected payoff is $\Phi - L(\Phi, q)$. Otherwise his (net) payoff is zero. If VC accepts the contract, his payoff is $p_h RF - F - \pi_{VC} = \Phi - \pi_{VC}$. Figure 3 summarizes the sequence of events that occur at date 2. Note that this specification of the sequence does not allow VC to duplicate the project after he has decided to accept E's offer and to finance the project. When the project is significantly profitable or VC can substantially differentiate its product from E's, VC may still have an incentive to duplicate the project and enter the product market competition with E. Nonetheless, to keep the model as simple as possible, I exclude this possibility and assume that the project is not profitable enough if two parties undertake it.[8]

[6] Here, I implicitly assume an equilibrium story in that VC should not finance E if E is unprofitable.

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

[8] Ueda (1997) discusses the case in which VC and E may enter the product market competition. The results would not change, however.

2.3 Equilibrium

This section solves and characterizes the equilibrium strategies of E, B, and VC. The solution concept adopted is perfect Bayesian equilibrium. Because an equilibrium must satisfy backward induction, the following exposition starts from date 2.

Before we proceed with solving the equilibrium, first note that hereafter "E's expected payoff" means E's *net* payoff that is equal to an incremental payoff due to a contract with either B or VC. E's expected payoff plus W is E's expected gross (or total) payoff. Second, note that any character marked with an overbar is associated with the case in which B observes the good signal, and any character that is underscored is associated with the case in which B observes the bad signal.

2.3.1 Equilibrium at Date 2

If VC declines E's offer of a contract, VC's optimal strategy is to expropriate E's project if $L(\Phi, q) \leq \Phi$ and not to expropriate if $L(\Phi, q) > \Phi$. To focus on an interesting case in that the VC's threat to expropriate is relevant, I assume that $L(\Phi, q) \leq \Phi$ hereafter. Under this assumption, if VC declines E's offer, VC's expected return is equal to $\Phi - L(\Phi, q)$. It is non decreasing in q, that is, VC has less incentive to expropriate the project if intellectual property rights are more securely protected. To persuade VC to accept the contract, E must guarantee VC a payoff of at least as much as $\Phi - L(\Phi, q)$. If VC accepts the offer from E, his expected payoff is $\Phi - \pi_{VC}$. Hence, $\pi_{VC} \leq L(\Phi, q)$ if VC accepts E's offer. As E's payoff is equal to π_{VC} and she wants to increase her payoff as much as possible, the following lemma is immediate.

lemma 1 *Let U^{VC} be E'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 VC captures a part of the rent to the project by threatening E with a possibility of expropriation.

2.3.2 Equilibrium at Date 1

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

2.3.3 Equilibrium at Date 0

Given E's optimal strategy just described, B offers a menu of contracts $\{\pi_R, \pi_0, T\}$. The optimal offer strategy of B will be solved in two steps. First, I derive the optimal offer if there were no VC such that E's payoff would be zero when she declined B's offer. This step gives the highest payoff that E could possibly get by financing from B if E is profitable. Let U^B denote this payoff. Hence, note that U^B is computed as if profitable E would accept the offer from B even though $U^B < U^{VC}$. 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. This implies that U^B will be computed so that profitable E would accept B's offer because accepting the offer gives a higher payoff than if E declines and cannot invest in the project. Second, we compare U^B with U^{VC} and see whether B, in equilibrium, wants to offer a contract to profitable E such that E gets U^B by accepting B's offer. If $U^B \geq U^{VC}$, B indeed wants to make a such an offer. Otherwise, B doesn't in equilibrium, because only the unprofitable type will accept the offer.

Now I start to derive the benchmark payoff U^B.

1. When $\overline{s}$ is observed; First, I examine the optimal offer when B observes the good signal, $\overline{s}$. B chooses a menu of contracts to offer so as to maximize the expected payoff for

profitable E

$$p_h\pi_R + (1-p_h)\pi_0 \ ,$$

subject to B's zero profit constraint

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

the incentive compatibility condition

$$p_l\pi_R + (1-p_l)\pi_0 \leq T \ , \tag{2}$$

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

$$\pi_0 \geq -W \ , \tag{3}$$

and the unprofitable E's participation constraint

$$T \geq 0 \ .$$

Note that the participation constraint of unprofitable E is stated but that of the profitable one is not. This is because we know the profitable E's payoff is always positive, owning to Bester's result.

lemma 2 *Without VC, the expected payoff for profitable E if B observes the good signal is*

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

the expected payoff for unprofitable E if she has the good signal is

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

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

Proof: First, note that B's zero-profit condition implies that $\alpha\left(\Phi - \overline{U^B}\right) - (1-\alpha)\,\overline{T^B} = 0$. Because $\overline{T^B} \geq 0$, $\overline{U^B} \leq \Phi$. Second, using B's zero-profit condition (1), the incentive compatibility condition (2) can be rewritten as follows:

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

Then, from (3), we have

$$\begin{aligned} p_h\pi_R + (1-p_h)\pi_0 &\leq p_h\frac{\alpha\Phi - \{(1-\alpha)(1-p_l) + \alpha(1-p_h)\}\pi_0}{\overline{p}} + (1-p_h)\pi_0 \\ &\leq \frac{\alpha p_h\Phi}{\overline{p}} + \left(\frac{p_h}{\overline{p}} - 1\right)W\ . \end{aligned}$$

Hence,

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

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

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

If $\Phi < \frac{\alpha p_h\Phi}{\overline{p}} + \left(\frac{p_h}{\overline{p}} - 1\right)W$, setting $\pi_0 = -W$, $\pi_R = \frac{(1-p_h)W+\Phi}{p_h}$, and $T = 0$, solves the optimization problem above and those values give $\overline{U^B} = \Phi$. Similarly, if $\Phi \geq \frac{\alpha p_h\Phi}{\overline{p}} + \left(\frac{p_h}{\overline{p}} - 1\right)W$, setting $\pi_0 = -W$, $\pi_R = \frac{\alpha\Phi+W}{\overline{p}}$, and $T = \frac{\alpha}{\overline{p}}\{p_l\Phi - (p_h - p_l)W\}$ solves the optimization problem above. Q.E.D.

2. When the bad signal is observed: B's problem when the bad signal is observed is identical to the one when the good signal is observed, EXCEPT that B's participation constraint (1) is replaced with

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

lemma 3 *Without VC, the expected payoff for profitable E if B observes the bad signal is*

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

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

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

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

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

Now I move to the second step in solving the equilibrium and introduce the possibility that profitable E can reject B's offer and meet with VC. In this case, B has to take into account that profitable E declines the offer from B if the contract intended for profitable E does not guarantee the payoff of at least U^{VC}. Note that $\overline{U^B}\left(\underline{U^B}\right)$ is the maximum payoff that B can guarantee to E if B sees the good (bad) signal and there were no VC. Thus, one can conclude that if $\overline{U^B}\left(\underline{U^B}\right) < U^{VC}$, B is never able to attract E, and E therefore finances from VC. If B sees the good (bad) signal and $\overline{U^B}\left(\underline{U^B}\right) < U^{VC}$, B's belief consistent with equilibrium is that only unprofitable E will accept or neither type of E will accept B's offer of contracts. In this case, B should make an offer such that there is no transfer between B and E in equilibrium. An example of such a contract is $\{\pi_R, \pi_0, T\} = \{-\varepsilon, -\varepsilon, -\varepsilon\}$, $\varepsilon < W$. On the contrary, if B sees the good (bad) signal and $\overline{U^B}\left(\underline{U^B}\right) \geq U^{VC}$, B can attract profitable E by offering a contract that gives E at least as much as U^{VC}. In conclusion, the following proposition follows lemmas 2 and 3.

proposition 1 *If E is profitable and B observes the good signal, then E finances from B if and only if*

$$\overline{U^B} \equiv \min\left[\Phi, \frac{\alpha p_h \Phi}{\overline{p}} + \left(\frac{p_h}{\overline{p}} - 1\right)W\right] \geq L\left(\Phi, q\right), \tag{4}$$

and she finances from VC otherwise. If E is profitable and B observes the bad signal, then E finances from B if and only if:

$$\underline{U^B} \equiv \min\left[\Phi, \frac{(1-\alpha)p_h \Phi}{\underline{p}} + \left(\frac{p_h}{\underline{p}} - 1\right)W\right] \geq L\left(\Phi, q\right); \tag{5}$$

otherwise, E finances from VC.

How about the payoff of unprofitable E? Roughly speaking, she can get some transfer from B in equilibrium only if she can "mimic" profitable E who finances from B in equilibrium. The ability to mimic profitable E who finances from VC does not help because VC can tell unprofitable E from profitable E.

To be concrete, let $\overline{I}(W, \alpha, \Phi, q)$ be an index function such that given p_h and p_l, $\overline{I} = 0$ if equation (4) is not satisfied and $\overline{I} = 1$ if equation (4) is satisfied, and let $\underline{I}(W, \alpha, \Phi, q)$ be another index function such that $\underline{I} = 0$ if equation (5) is not satisfied and $\underline{I} = 1$ if equation (5) is satisfied. In other words, the index functions $\overline{I}$ and $\underline{I}$ map E's characteristics into her choice of financing source. If E is profitable and B observes the good (bad) signal and her characteristics give $\overline{I}(\underline{I}) = 0$, then she finances from VC. If E is profitable and B observes the good (bad) signal and her characteristics give $\overline{I}(\underline{I}) = 1$, she finances from B. Using notation, the payoff of unprofitable E is $\overline{T}(\underline{T})$ if E is profitable and B observes the good (bad) signal and her characteristics give $\overline{I}(\underline{I}) = 1$. This is because B rationally believes that profitable E whose characteristics give $\overline{I}(\underline{I}) = 1$ accepts the offer and that the expected gain from lending to profitable E can compensate the expected loss from a non-negative transfer to unprofitable E. The payoff of unprofitable E is zero if she has the good (bad) signal and her characteristics give $\overline{I}(\underline{I}) = 0$.

3 Empirical Implications

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

3.1 Low-Collateral Entrepreneur Goes to VC

It is commonly observed that a bank requires collateral when making loans whereas a venture capitalist does not. This observation is confirmed in this model.

corollary 1 *Both $\overline{I}$ and $\underline{I}$ are non decreasing in W; that is, profitable E finances from VC*

if her collateral is low and from B if her collateral is high.

Proof: The proposition follows that the left-hand sides of both equations (4) and (5) are non decreasing in W.

Figure 4 visualizes this corollary by plotting $\overline{U^B}$, $\underline{U^B}$, and U^{VC} $(= L)$. U^{VC} is constant and does not depend on W, whereas both $\overline{U^B}$ and $\underline{U^B}$ are increasing in W. As a consequence, VC is a more attractive source of financing relative to B when E's collateral is low. This is because E and VC contract without asymmetric information whereas E and VC contract under asymmetric information. As the collateral increases, B can recover a higher amount of the loan even if the project fails and can penalize unprofitable E more harshly if she has chosen the contract meant for profitable E. Due to this tougher punishment, unprofitable E is willing to accept a lower amount of the transfer, T, and B can decrease the expected loss in case E turns out to be the unprofitable type and can increase π_R without violating the zero-profit condition. As a consequence, profitable E can obtain better contract terms from B. If we interpret $(RF - \pi_R)/F$ as the interest rate that B charges to profitable E, 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 if the entrepreneur's collateral is high, the interest rate becomes low. In an extreme case, if her collateral is no less than

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

profitable E can capture the entire rent of the project as she would if there were no asymmetric information. Further, $\overline{U^B} > \underline{U^B}$ if $W < W_B$. When E is profitable and B observes the good signal, E can enjoy a lower rate of interest than when B observes the bad signal. This is because when the good signal is observed, B believes that E is unlikely to turn out to be the unprofitable type. Thus, to break even B can set a lower rate of interest than when B observes the bad signal. As a consequence, the threshold amount of collateral at which E switches between B and VC is lower if B observes the good signal than if B observes the bad

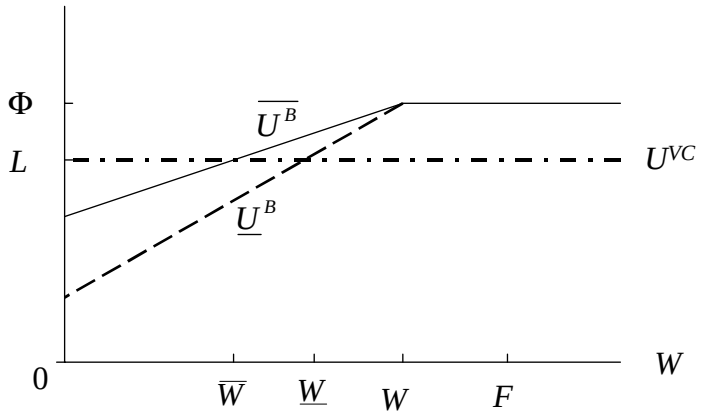


Figure 3: Comparative Statics on Collateral

signal. (In figure 4, the threshold for E with whom B observes the good signal is denoted by $\overline{W}$ and that for E with whom B observes the bad signal is denoted by $\underline{W}$, respectively.)

3.2 Tight Protection of IPR Drives E to VC

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

corollary 2 *Both $\overline{I}$ and $\underline{I}$ are non increasing in q; that is, profitable E finances from VC if the intellectual property rights to her project are securely protected, and from B if they are not.*

Proof: The proposition follows that the right-hand sides of both equations (4) and (5) are non decreasing in q.

When E holds secure property rights to her project, VC's threat to expropriate the project becomes weak. In the extreme case that $L(\Phi, q)$ is as much as Φ, VC's threat is not effective at all. Thus, in this case, E discloses the project to and finances from VC because E only benefits from VC's superior identification skill and does not suffer from VC's threats to copy E's project.

This proposition suggests that the choice of financing source depends on the legal environment that determines the degree of protection of intellectual property rights. For instance, the U.S. patent office is known to be more generous in approving patents as compared to its counterparts in other countries. The U.S. office began to approve software patents prior to in any other countries and further, it is the only such office that grants patents to business models. Hence, strong protection of intellectual rights may be one reason that the U.S. has a bigger VC market than other countries.

Not only cross-country difference of the venture capital market, but also the time series of the U.S. venture capital investment is consistent with the model. As shown in Figure 1, for instance, the rapid growth of VC in the late 1990s might have been driven by the introduction of business model patents. During this time, the U.S. patent office extended the definition of "novelty" and started to grant patents to business ideas or models. As a consequence, 1999 saw a heated debate on the patenting of business ideas. For instance, an editorial in the December 1999 issue of Computerworld 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 U.S. Court of Appeals for the Federal Circuit made clear that methods of doing business were not beyond the purview of patent protection. (Electronic Business, Jan. 2000). Interpreting this pro-patent policy as a tightening of intellectual property protection, the model explains why venture capital has grown so fast in recent years. Stronger protection of property rights may account not only for the recent growth of VC but also for its growth in the early 1980s. In 1982, Congress established the Court of Appeals of the Federal Circuit. The new court has been widely regarded as being tougher than ever before in enforcing intellectual property rights (Merges 1992).

3.3 A Large Project Financed by VC

Which funding sources bank or VC does makes bigger investment? Kaplan and Stromberg (2000) find that venture capitalists invest a median of $4.5 million in their portfolio companies at each stage. This seems quite big compared to the amount that banks lend to start-up firms. As a rough comparison, since 1996 the U.S. Small Business Administration has defined a loan of less than $1 million as a proxy for small business lending since 1996. Considering that start-up firms are small, 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 E finances from VC if F is large?

The model as it is does not provide a definitive answer to this question. Note that $\overline{I}$ and $\underline{I}$ are not always non increasing in F because both sides of equations (4) and (5) are non decreasing in F. Roughly speaking, if F is larger, expected payoff of profitable E is higher regardless of whether she finances from B or VC. 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. Judges typically order an infringer of intellectual property rights to pay to the legal owner of the rights the value of the property infringed, 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 VC has to pay if he were to copy E'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 *Both $\overline{I}$ and $\underline{I}$ are non increasing in F; that is, E finances from VC if E's project is large and from B if it is small.*

Proof: 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.

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

then if $F \leq F^*$, $\overline{U^B} = \underline{U^B} = (p_h R - 1) F$. Thus, E can appropriate the entire rent to the project by financing from B. On the other hand, $\overline{U^{VC}} < (p_h R - 1) F$ because $U^{VC} = q (p_h R - 1) F$ and $0 \leq q < 1$. As a result, if $F \leq F^*$, both $\overline{I}$ and $\underline{I}$ are equal to one (that is, E finances from B).

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

$$\overline{U^B} \equiv \frac{\alpha p_h \Phi}{\overline{p}} + \left(\frac{p_h}{\overline{p}} - 1 \right) W \ , \tag{6}$$

and

$$\underline{U^B} \equiv \frac{(1-\alpha) p_h \Phi}{\hat{p}} + \left(\frac{p_h}{\hat{p}} - 1 \right) W \ . \tag{7}$$

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 6 illustrates how E's payoff changes in F. If $F \leq W$, E can finance the project by issuing a risk-free debt. If $W < F \leq F^*$, E can still appropriate all return to the project by financing from B since the asymmetric information problem is completely circumvented through B's threat to seize E's collateral. If $F > F^*$, the asymmetric information becomes costly such that B has to bribe unprofitable E by a positive transfer T in order to screen profitable projects from unprofitable ones. This also costs profitable E because B 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, free from the asymmetric information problem, U^{VC} is linear in F everywhere and strictly smaller than $\overline{U^B}$ and $\underline{U^B}$ if F is small enough.

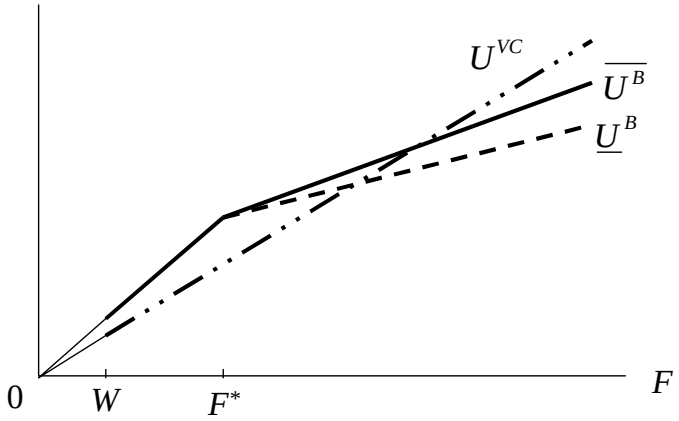


Figure 4: Comparative Statics on Project Size

Consistent to the prediction of the model, Hellmann and Puri (2000) find that in Sillicon Valley venture-backed firms hire more employees than non-venture-backed firms.

3.4 High-Rate-of-Return Project Goes to VC

Maintaining the assumption $L = q\Phi \equiv q\left(p_h R - 1\right) F$, the model also implies that E tends to finance from VC if the rate of return to the project is high:

corollary 4 *Both $\overline{I}$ and $\underline{I}$ are non increasing in R; that is, E finances from VC if E's project has a high rate of return and from B if it has a low rate of return.*

Proof: Similar to the proof of corollary 3.

Note that since the expected profit $\left(p_h R - 1\right) F$ is increasing in both R and F, corollaries 2 and 3 suggest that E with a high-profitability project tends to go to VC.

3.5 High-Risk Project Financed by VC

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% of the sample generated a complete loss (-100%) for the investors. The median return was only 4%, 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). In the model, project risks also drive entrepreneurs to finance from VC rather than B.

The variance of the return is

$$p_h \left(R - p_h R\right)^2 + \left(1 - p_h\right) \left(-p_h R\right)^2 = \frac{1 - p_h}{p_h} \left(p_h R\right)^2 .$$

Hence, given return $p_h R$ constant, the lower the p_h, the riskier the project.

corollary 5 *Given $p_h R$ constant, both $\overline{I}$ and $\underline{I}$ are non increasing in p_h; that is, B finances the safe project and VC finances the risky project.*

Proof: Similar to that of corollary 3.

Intuitions behind this proposition are as follows. As p_h goes down, 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 B. As a consequence, financing from B becomes expensive, and marginal E switches from B to VC.

3.6 High-Tech Entrepreneur Goes to VC?

Another stylized fact is that high-tech firms often raise funds from venture capital. The variable in this model that best captures "high-techness" is α. The lower the α is, the more often B makes mistakes in evaluating the profitability of the project. Because understanding business plans of high-tech firms requires technological expertise, venture capital presumably has a strong advantage relative to commercial banks in evaluating these kinds of projects . An interesting question then is how α affects the choice of the financing source in the model. 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 B sees the good signal, this is not as good a sign as before and therefore B offers a more conservative contract intended

for profitable E in order to break even. If B sees the bad signal, this is not as bad a sign as before and therefore B can offer a contract intended for profitable E, which guarantees a higher payoff than before. To be concrete, $\overline{U^B}$ is increasing in α while $\overline{U^B}$ is decreasing in α. The first effect drives E to get away from B and to finance from VC, 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 from VC.

4 Discussion

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

4.1 Can Contracts Prevent Expropriation?

The preceding discussion argued 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 E and VC write a contract such that VC must pay a penalty for expropriation beyond the stipulated amount of the legal penalty? I believe not, for the same reason that it is difficult to sell information. Unlike the selling of goods and other services, selling information requires the seller not to reveal its content in advance to the buyer of the information. This is because in the absence of the complete protection of that information revealing it makes it possible for the buyer to use the information without paying for it. On the other hand, if the seller tries to hide the content of the information, the buyer is not willing to pay for such information because its content may turn out to be useless to the buyer. This difficulty with selling information presumably prevents E and VC from writing a contract that imposes a huge penalty on expropriation.

There are two points at which E and VC can possibly write such a contract. The first is *after* E reveals the content of the project to VC. Similar to the preceeding argument, VC has already acquired the content of the project and can use this information without paying

E. Thus VC prefers not to agree to such a contract. The second time for writing such a contract is *before* E reveals the content of the project to VC. Nonetheless, VC has not yet learned the content of the project and hence all the parties can is to write a contract such that VC must pay a huge penalty to E if VC infringes on ANY of E's intellectual property. Similar to the preceding argument, VC presumably prefers not to write such a contract due to asymmetric information problems. Without knowing what E knows, committing not to use the same ideas as E's reduces VC's flexibility in that VC has to limit its scope of projects to areas in which E is not knowledgeable and presumably should not have developed any projects.

4.2 Why Does B Not Consult VC?

B may be able to avoid making mistakes in assessing the project by hiring VC just to evaluate E's project. In this case, however, E would not want to disclose the project to B because B would be able to require a high rate of return by threatening E that VC may copy the project. The inability to understand E's project accurately may be B's advantage since B can commit not to imitate E's idea.

4.3 In Reality, Does a Bank Offer a Menu of Contracts?

I assumed that B offers a menu of contracts to distinguish the quality of entrepreneurs. How does B do this in practice? Although banks (unlike insurance companies) do not seem to offer menus of contracts explicitly, other elaborate financial arrangements may overcome the problem of adverse selection. For instance, commercial banks sometimes offer favorable terms for large sums of deposits. This may work to screen unprofitable entrepreneurs since such entrepreneurs prefer a high, safe return over a risky contract that is meant to attract profitable entrepreneurs. Staging of finance may also function as a screening device: B 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. A profitable entrepreneur will be confident enough

that he or she will accomplish the project to borrow the full amount required, whereas an unprofitable entrepreneur will not want to borrow at the later stage.

Furthermore, suppose that B offers a single rate of interest, as is assumed in much of the banking literature (e.g., Stiglitz and Weiss 1981; De Meza and Webb 1987). All corollaries presented earlier are robust to this change of assumption. To see this point, consider the model in which B offers a single interest rate r to E rather than a menu of contracts. This loan contract specifies that B seizes a whole amount of W from E if the project returns zero, and E pays $(1+r)F$ to B if the project returns RF. Under this loan contract, profitable E's expected payoff is $p_h[RF-(1+r)F]-(1-p_h)W$. If there were no possibility for E to turn to VC, the zero-profit condition of B determines the interest rate as follows:

$$\begin{aligned} \overline{p}(1+r)F+(1-\overline{p})W &= F \text{ if } s=\overline{s} \text{ and} \\ \underline{p}(1+r)F+\left(1-\underline{p}\right)W &= F \text{ if } s=\underline{s}\,. \end{aligned}$$

These conditions imply that profitable E's expected payoff is

$$\begin{aligned} p_h\left(R-\frac{1}{\overline{p}}\right)F+\left(\frac{p_h}{\overline{p}}-1\right)W \text{ if } s &= \overline{s} \text{ and} \\ p_h\left(R-\frac{1}{\underline{p}}\right)F+\left(\frac{p_h}{\underline{p}}-1\right)W \text{ if } s &= \underline{s}\,. \end{aligned}$$

These payoffs are very similar to $\overline{U^B}$ and $\underline{U^B}$: linear and increasing in R, F, and W. Thus, all corollaries proved in the original model remain unchanged even when B is restricted to offering a single interest rate to E.

4.4 Timing

In this paper, I assumed that E first negotiates with B, and only if the bargaining between E and B fails E negotiates with VC. What if E can choose either B or VC 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 VC finances richer types of E than those under the original timing assumption. This is because

belief is self-enforcing. If B believes that the profitable entrepreneur finances from VC, then only unprofitable E comes to negotiate with B. As a consequence, B does not offer an attractive term of contracts to such an entrepreneur, and then this belief induces profitable E to negotiate with VC first.

Nonetheless, introducing a small bounded rationality of B, these kinds of equilibria do not survive, and only the equilibrium under the original timing assumption survives. Suppose that even with a very small probability, B may give a term of contract that is better than the one that VC would offer. E then always chooses to negotiate with B first, because disclosing the project to B does not invite a threat of expropriation and is costless. Knowing that profitable E negotiates with B first, the timing is much like that in the original model. In this way, a small bounded rationality induces any type of profitable E to negotiate with B first. Hence, the timing assumption in the model is robust in allowing E to choose the sequence of the negotiation.

5 Conclusion

In this paper, I studied the choice of financing sources when venture capitalists can assess an entrepreneur's idea better than banks can. Although this assessment advantage makes financing from VC attractive, such financing entails the cost of revealing technological information and inviting the threat of expropriation by VC. When an entrepreneur finances from 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 bank and VC 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, high growth, high return, and high risk of the project all create a cost of the asymmetric information and thereby drive the entrepreneur to finance from VC. Stronger protection of intellectual property rights weakens the threat that VC may expropriate the entrepreneur's

project, and thereby the entrepreneur tends to finance from VC. These implications of the model are consistent to the stylized feature of venture-backed firms and the recent dramatic growth of the venture capital industry.

Although the paper has focused on the comparisons between VC and banks, the model also applies to various financiers that are different in their degree of technological expertise.[9] What I call VC in the model can be business angels, strategic investors, or both because they are ongoing users of technology and their familiarity with that technology possibly helps them screen as well as expropriate projects.

[9] Leshchinskii (2000) differentiates between business angels and VC by assuming that a business angel is wealth constrained whereas VC is not. As a consequence, VC can invest in a large portfolio of firms and become tough in shutting down one or many ventures in the portfolio.

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