

ENTREPRENEURIAL ABILITY, VENTURE INVESTMENTS, AND RISK SHARING*

RAPHAEL AMIT, LAWRENCE GLOSTEN AND EITAN MULLER

*Faculty of Commerce and Business Administration, University of British Columbia,
Vancouver, B.C., V6T 1Y8 Canada*
Graduate School of Business, Columbia University, New York, New York 10027
*Recanati Graduate School of Business Administration, Tel-Aviv University,
Tel-Aviv, Israel 69978*

A number of issues that relate to the desirability and implications of new venture financing are examined within a principal-agent framework that captures the essence of the relationship between entrepreneurs and venture capitalists. The model suggests: (1) As long as the skill levels of entrepreneurs are common knowledge, all will choose to involve venture capital investors, since the risk sharing provided by outside participation dominates the agency relationship that is created. (2) The less able entrepreneurs will choose to involve venture capitalists, whereas the more profitable ventures will be developed without external participation because of the adverse selection problem associated with asymmetric information. (3) If a costly signal is available that conveys the entrepreneur's ability, some entrepreneurs will invest in such a signal and then sell to investors; these entrepreneurs, however, need not be the more able ones. The implications for new venture financing of these and other findings are discussed and illustrated by example. (ENTREPRENEURSHIP; VENTURE CAPITAL; ADVERSE SELECTION; MORAL HAZARD; RISK REDUCTION)

1. Introduction

Numerous studies in the management and economics literature address qualitatively important and fundamental issues about entrepreneurs, their activities and behaviors, and the process of new venture formation. Baumol (1968), Drucker (1985), Kirzner (1985), Leibenstein (1968), MacMillan, Siegel and Narasimha (1985), MacMillan, Zemann and Narasimha (1987), Rumelt (1987), Schumpeter (1942), Teece (1987), Tyebjee and Bruno (1984) and others elaborate on the roles of entrepreneurs, their main characteristics, how they differ from managers, and the market functions of entrepreneurship. Relatedly, this literature also explores the essential elements of new venture formation, how value is created through the entrepreneurial process, and how venture investments are made by venture capital firms.

In addition, there are many descriptive field and empirical studies of the same issues that provide insights about entrepreneurs, their ventures in both independent and corporate settings, and the activities of venture capital firms. (See, for example, Tyebjee and Bruno 1984; Van de Ven, Hudson and Schroeder 1984; Timmons 1985; Brophy 1986; MacMillan and Day 1987; Cooper and Bruno 1987; Day 1988; and a comprehensive literature review by Low and MacMillan 1988.) Supplementing the descriptive and qualitative body of literature are manuscripts that provide rules-of-thumb and common wisdom criteria for developing new ventures (e.g., Brandt 1982), but which have no theoretical foundations.

However instructive, the received literature offers neither a predictive theory of the behavior of entrepreneurs nor much in the way of guidance for practice. That it is important to fill both of these gaps is evidenced by the great increases in entrepreneurial activity over the past two decades, accompanied by the high failure rate of new ventures.

* Accepted by Diana L. Day, John U. Farley, and Jerry Wind.

In fact, a recent study (Bygrave, Fast, Khoylan, Vincent and Yue 1988) documents the alarmingly low rates of return for venture capital funds. (The mean IRR was less than 10% by the end of 1985.) As investors may seek compound annual rates of returns in excess of 70% for early stage financing, the reported low average return reflects the high failure rate of entrepreneurial ventures. Among the intuitive explanations for this phenomenon are poor risk management by entrepreneurs, the availability to investors of inherently less profitable ventures, bad luck, or the inability of the venture capitalists to evaluate adequately the abilities of entrepreneurs to turn their ideas into viable enterprises.

The purpose of this study is to investigate analytically these and other issues that relate to the behavior of entrepreneurs, focusing on the decisions of entrepreneurs to develop their ventures independently or with venture capitalists. Within a principal-agent framework that captures the essence of the venture capital/entrepreneur relationship, we examine a number of unanswered theoretical questions including: who decides to enter into an agreement with outsiders? Why? How is this decision related to the unobservable ability of the entrepreneur, the desire to share risk, or the need for capital? Would it be worthwhile for the entrepreneur to expend resources to convey his ability to outside investors before involving them in the venture?

2. Entrepreneurs and Entrepreneurial Ventures

No clear definition prevails as to what constitutes the creation of an entrepreneurial venture; however, the act of innovation that involves endowing existing resources with new wealth-producing capacity (Drucker 1985) is central to the conceptualization. The innovation that lies at the heart of the entrepreneurial activity is not restricted to a technological invention which results from R&D or to an innovative cost-reducing process. It may simply involve a new application of existing technologies, a product or a service innovation, or a new way or place of doing business. Whatever form it takes, however, there is a substantial amount of ex-ante uncertainty about the wealth-producing capacity of the newly created capital. This uncertainty has two main sources. The feasibility and market acceptance (or the production and demand functions) of the innovation and the pace at which imitation will erode the extraordinary profit from the innovation are unknown ex-ante (see Kamien and Schwartz 1982; Teece 1987, Chapter 9). If the imitation is instantaneous, then no surplus entrepreneurial profits will result. The source of the entrepreneurial rents that may be inherent in the innovation is the rareness, limited imitability and tradeability and importance to customers of the bundle of firm-specific assets that are created by the entrepreneur.

Our conceptualization of an entrepreneurial activity suggests that it centers on the entrepreneur's *ability* (talent, skill, experience, ingenuity, leadership, etc.) to combine tangible and intangible assets in new ways and to deploy them to meet customer needs in a manner that could not easily be imitated. This ability may be known to the entrepreneur but unknown to outsiders, such as venture capitalists. The inability of outsiders to assess the venture founders' core attributes, namely their entrepreneurial skills and abilities, may affect both the decisions of entrepreneurs to involve outsiders and the prices venture capital firms may be willing to pay for new ventures. Indeed, our discussion explicitly considers this asymmetry of information.

3. Related Literature and Model Overview

Surprisingly little theoretical, quantitative, and rigorous literature focuses on decisions of entrepreneurs to develop their ventures and the bases for entrepreneurial investment decisions. In fact, the issue of involving venture investors does not typically arise because research begins with the assumption that outside financing is required to develop the venture (Chan, Siegel, and Thakor 1987; Hirao 1988). Presumably, at some cost to the

venture's future profits, an able entrepreneur might be willing either to forgo outside investment or to borrow funds personally.

Kihlstrom and Laffont (1979) consider a related issue. In a general equilibrium framework under uncertainty, they focus on risk aversion as the determinant that explains which individuals become entrepreneurs and which work as laborers. They implicitly assume that all potential entrepreneurs are equally able, and find that, at equilibrium, the less risk-averse individuals become entrepreneurs, while the more risk-averse choose to become laborers. As not all potential entrepreneurs may be equally able or equally industrious in the development of their venture, it seems useful to consider these attributes along with the risk-bearing aspects of new venture formation in a formal analysis.

In our model, the entrepreneur is characterized as having some given level of ability. He chooses the level of effort he is willing to expend and the level of capital investment required to form the venture and to realize an uncertain payoff. Thus, the size of the expected state-contingent ultimate payoff is a function of the ability of the entrepreneur, the level of effort expended, and the capital invested.

In order to analyze whether the entrepreneur should develop the venture independently or with outside equity investors, we posit that a distinguishing feature of the entrepreneur's reward system is the relationship between the ultimate profits from the venture and his share. The independent entrepreneur is rewarded by the entire profits, whereas the entrepreneur who involves outsiders may only be rewarded by some fraction of future profits. When equity investors are involved, we allow the form of the sharing agreement of the ultimate payoff to be chosen by them. Indeed, the sharing of ultimate payoff between the entrepreneur-manager and the venture capitalist, who both face risk, is consistent with stylized facts about venture capital contracts. (See Chan, Siegel, and Thakor 1987 for details.) Our model considers the risk bearing aspects as well as the ability and efforts of the entrepreneur in determining the sharing arrangement.

Admittedly, we take an extreme view in that we consider the decision to involve investors as an "all or nothing" decision. Once the decision is made, the entrepreneur is assumed to turn over to the investors the right to determine the sharing arrangement. The investors, in turn, maximize their profits by determining the entrepreneur's share of ultimate payoff, the size of their new investment, and the entrepreneur's level of effort, a point to which we shall return.

Our model is designed to predict which entrepreneurs will decide to enter into an agreement with venture capitalists. We note here that our first result, using a model in which investors are risk neutral and the entrepreneur is risk averse, predicts that every entrepreneur will wish to involve outsiders. We find that as long as there is no private information about the skill of the entrepreneur, entrepreneurs will sell out to investors. This occurs because the risk sharing provided by outside participation dominates the agency relationship that is created.

The prediction is strong, and armchair empiricism would suggest that such action is not consistent with observed behavior, since some entrepreneurs do not sell out. Presumably they do not do so because they do not expect to get full value for their ideas, either because of noncompetitive aspects in the capital markets or because the entrepreneur and outsiders have different information about the venture's potential. Our focus is on the latter explanation. The conclusions of the analysis of the model with asymmetric information are that: (1) As long as the pool of projects is good enough and the entrepreneur is slightly risk averse or his need for new funds is not trivial, there will always be some entrepreneurs who will sell out; (2) If only a proportion of entrepreneurs sell out, it is the less profitable ventures—those started by less capable entrepreneurs—that are sold, whereas the more profitable ventures are retained by the more skillful entrepreneurs; and (3) Under certain circumstances, it becomes worthwhile for the entrepreneur to expend resources to convey his ability to outsiders before settling on a contract.

For the purposes of this study, we focus on the behavior of a risk-averse entrepreneur in an independent setting who seeks to maximize expected utility of terminal wealth.

4. The Model

We follow the methodology of a principal-agent problem (Harris and Raviv 1978; Holmstrom 1979), and let X denote the random profits from the venture, gross of any new investment. The density of X depends upon the endowed skill level of the entrepreneur, denoted by γ ; his chosen level of activity (or effort), denoted by a ; and the magnitude of investment in the venture, denoted by I . Formally, let $f(x; \gamma, a, I)$ denote the density of the profits evaluated at the realization x , for an entrepreneur with skill level γ , when activity a and a new investment I are chosen. We assume that larger values of γ , a , and I lead to a first order stochastic dominance relation. Thus, letting $f_i(x; \gamma, a, I)$ denote the derivative of the density with respect to the i th parameter, $\int h(x)f_i(x; \gamma, a, I) > 0$ for any increasing function $h(\cdot)$ and for $i = \gamma, a, I$.

First we formulate the problem of an unfettered entrepreneur. He has a utility function U (increasing and concave) defined over future wealth. Furthermore, there is disutility associated with choosing larger levels of activity a . We assume that the utility of wealth and the disutility of the activity are separable. Thus, the utility of payoff x when activity a is chosen is $U(x) - V(a)$, where $V(\cdot)$ is normalized so that it is zero when there is no activity.

The entrepreneur who develops the venture on his own has the option of using his own assets, or he may borrow fully collateralized funds (i.e., the lender is not making a risky loan) to develop the venture. Let $B(I)$ be the cost of raising I where $B(I) \geq I$. A strict inequality may hold when borrowing occurs. This entrepreneur therefore chooses a and I in order to maximize expected utility given by

$$\text{Maximize}_{a,I} \int U(x - B(I))f(x; \gamma, a, I) - V(a). \tag{1}$$

Let $u^*(\gamma)$ denote the maximum utility in (1), and let a_e and I_e be respectively the optimal activity level and the investment chosen by the entrepreneur.

Should the entrepreneur choose to involve outside investors, we presume that the following sequence of events occurs. The entrepreneur solicits bids for the company, and takes the maximum bid w . This bid is a fixed amount of capital which is independent of the entrepreneur’s demonstrated skill and eventual profits from the venture. It is paid to the entrepreneur in case he decides not to continue with the venture after the sale to investors or in case the investors decide to relieve the entrepreneur from productive control. If the entrepreneur stops managing, he is enjoined from pursuing the activity. This amount w is commonly referred to as the buyout option in venture capital contracts (Chan, Siegel, and Thakor 1987).

After accepting the bid w , the entrepreneur cedes the right of determining his share of the ultimate payoff to the venture capital investors. As the entrepreneur’s skill level γ will eventually be revealed, we assume that when the sharing agreement is made γ can be contracted on directly.¹ The risk neutral investors therefore determine their investment level I , the entrepreneur’s activity level a , and the entrepreneur’s share of ultimate profits $s(x)$, so as to maximize their profits. This maximization is subject to the entrepreneur’s willingness to manage the venture after he sells out to investors and to an incentive compatibility constraint on the activity choice. Consistent with the principal-agent lit-

¹ If the ability of the entrepreneur is not known when the sharing agreement is determined, then a revelation contract (or sorting condition) that will induce the entrepreneur to report his true ability is required. It is, however, beyond the scope of this study to consider a setting that includes the revelation game.

erature (Holmstrom 1979), the actual actions chosen cannot be observed. Specifically the investors' problem is to maximize profits (the support of x does not depend on the activity level a):

$$\text{Maximize } \int_{a, I, s(\cdot)} (x - s(x))f(x; \gamma, a, I) - I \quad (2)$$

s.t.

$$\int U(s(x))f(x; \gamma, a, I) - V(a) \geq U(w), \quad (3)$$

$$a \text{ maximizes } \int U(s(x))f(x; \gamma, a, I) - V(a). \quad (4)$$

Assuming a solution exists, let $\text{NPV}(w, \gamma)$ denote the maximized value of the objective function (2). Inequality (3) states that the entrepreneur is at least as well off after he expended the effort a to develop the venture as he would have been had he walked away from it with the buyout payment w . Constraint (4) insures incentive compatibility; that is, it assures the investors that the entrepreneur will choose their profit maximizing level of effort.

If, during the bidding, the skill level of the entrepreneur is known to the outside investors, then competition among potential investors will determine the bid $w(\gamma)$ which, as long as the set is nonempty, satisfies

$$w(\gamma) = \max \{ w : \text{NPV}(w, \gamma) \geq 0 \}. \quad (5)$$

It can be verified that $\text{NPV}(w, \gamma)$ —the maximized value of the objective function—is continuous in w .

If the skill level of the entrepreneur is not known during the bidding, then competition among investors will lead to a bid so that investors expect a zero NPV investment. This expectation is taken over the skill level the investors expect to face.

5. Bidding with Common Knowledge

We first analyze the case in which the skill level is common knowledge during the bidding for the venture. Our first result concerns the consistency of the model. We prove that as long as the project is worthwhile to the entrepreneur—that is, $u^*(\gamma) \geq U(0)$ —there is a $w(\gamma)$ which makes the investment a zero net present value one. The existence of such a price is shown by arguing that if the investors pay zero for the venture, then it is a nonnegative NPV investment. Furthermore, if they pay a very high price it will be a negative NPV investment. By continuity, there is a w that makes the venture a zero NPV investment.

PROPOSITION 1. *Assume that for a skill level γ , the entrepreneur finds the venture attractive; that is, $u^*(\gamma) \geq U(0)$. Then there exists a nonnegative $w(\gamma)$ satisfying $\text{NPV}(w(\gamma), \gamma) = 0$.*

PROOF. See the Appendix.

Having established the consistency of the relationship between the investors and the entrepreneur, we now address the issue of the entrepreneur's decision to sell out. Before presenting the result, we note the intuitively appealing observation that $\text{NPV}(w, \gamma)$ is nonincreasing in w , because increasing w increases the minimum utility that the entrepreneur must enjoy. This imposes a direct cost on the investors.

LEMMA 1. *The function $\text{NPV}(w, \gamma)$, the present value of the investment to the investors, is decreasing in the payment w .*

PROOF. Consider $w_1 > w_2$ with associated optimal solutions (s_1, a_1, I_1) and (s_2, a_2, I_2) . Note that

$$\int U(s_1(x))f(x; \gamma, a_1, I_1) - V(a_1) \geq U(w_1) > U(w_2).$$

Thus, s_1, a_1, I_1 is feasible for the problem with w_2 . Hence,

$$\begin{aligned} \text{NPV}(w_1, \gamma) &= \int (x - s_1(x))f(x; \gamma, a_1, I_1) - I_1 \\ &\leq \int (x - s_2(x))f(x; \gamma, a_2, I_2) - I_2 = \text{NPV}(w_2, \gamma). \quad \text{Q.E.D.} \end{aligned}$$

We next show that every entrepreneur facing competitive investors will choose to sell out. The result is derived by showing that a *feasible* strategy for the investors is to offer a compensation contract which mimics the payoffs the entrepreneur could expect on his own. However, the investors can construct a better contract by absorbing some of the risk. Thus, if the investors could offer an amount which would lead to the entrepreneur's indifference between selling out and developing the venture alone, the investment would be a nonnegative NPV investment. Since the competitive bidding insures that the investment will be a zero NPV investment, the investors in equilibrium will offer more than the amount needed to make the entrepreneur indifferent between retaining the venture and selling.

PROPOSITION 2. *Assuming that ability level is common knowledge at the time of the bidding, every entrepreneur will find it optimal to sell off the firm. That is,*

$$u^*(\gamma) \leq U(w(\gamma)) = \int U(s^*(x))f(x; \gamma, a^*, I^*) - V(a^*),$$

where $s^*(\cdot)$, a^* and I^* are the optimizers for the principal-agent problem in (2)–(4).

PROOF. We need to prove that $w(\gamma) \geq U^{-1}(u^*(\gamma))$, which can be established by showing that

$$\text{NPV}(U^{-1}(u^*(\gamma)), \gamma) \geq 0$$

and by using the above lemma.

$$\begin{aligned} \text{NPV}(U^{-1}(u^*(\gamma)), \gamma) &= \underset{s(\cdot), a, I}{\text{Maximize}} \int (x - s(x))f(x; \gamma, a, I) - I \\ &\text{s.t.} \\ &\int U(s(x))f(x; \gamma, a, I) - V(a) \geq U^*(\gamma), \\ &a \text{ maximizes } \int U(s(x))f(x; \gamma, a, I) - V(a). \end{aligned}$$

A feasible contract, action, and investment triple is $s(x) = x - B(I_e)$, a_e, I_e . So

$$\begin{aligned} \text{NPV}(U^{-1}(u^*(\gamma)), \gamma) &\geq \int (x - x + B(I_e))f(x; \gamma, a_e, I_e) - I_e \\ &= B(I_e) - I_e \geq 0. \quad \text{Q.E.D.} \end{aligned}$$

We note several aspects of this result. First, the need for new investment is not critical to the results; it makes them stronger. The incentive to share risk is large enough to make

the proposition true even if the density of the profits does not depend upon the new investment I . Strict preference does depend upon risk aversion. If the entrepreneur is risk neutral, then we know that the first best can be obtained in the principal-agent problem as well as when the entrepreneur works alone. Thus, if the entrepreneur is risk neutral, he is indifferent between retaining the firm or selling out. Of course, if the entrepreneur is risk neutral but faces difficulty in raising new investment (i.e., $B(I) > I$), then he will prefer to sell out. In such a way, the first best is obtained with the optimal amount of new investment, which is better than developing the venture without external participation.

Furthermore, it can be verified that the utility achieved by the entrepreneur who involves outside investors in the venture is equal to the utility achieved if competition among investors solves the following problem:²

$$\text{Maximize } \int_{s(\cdot), a, I} (U(s(x))f(x; \gamma, a, I) - V(a)) \quad (6)$$

s.t.

$$\int (x - s(x))f(x; \gamma, a, I) - I \geq 0, \quad (6a)$$

$$a \text{ maximizes } \int U(s(x))f(x; \gamma, a, I) - V(a). \quad (6b)$$

It should be noted that the entrepreneur need not enjoy limited liability; that is, $s(x)$ is not restricted to being nonnegative. Certainly, the entrepreneur has no interest, ex ante, in insisting upon limited liability. This can be seen by noting the equality of the utility achieved in our modeling of the relationship and that of Chan, Siegel and Thakor. Restricting $s(x)$ to be nonnegative in the second formulation (problem (6)–(6b)) will lead to no greater expected utility, and if the nonnegativity constraint is binding there will be lower expected utility. On the other hand, our failure to restrict $s(x)$ may be inconsistent with bankruptcy law. That is, the contract may not be enforceable in states in which $s(x)$ is negative. The results above will go through if we restrict $s(x)$ to be greater than or equal to $[\underline{x} - B(I_e)]$, where \underline{x} is the smallest possible realization of X . That is, if the entrepreneur's problem, as we have formulated it, is consistent with bankruptcy law, then $s(x)$, so restricted, is consistent with bankruptcy law (and hence enforceable) and our results remain intact.

6. Bidding with Asymmetric Information

Since entrepreneurs do not always sell out, another explanation must be sought. We suspect that it lies in private information about the skill level. The problem can be seen by considering an extreme case. Suppose the entrepreneur is risk neutral and there is no need for new investment. If the investors price the firm based on the average skill level, then only those entrepreneurs with ability below the average will sell out. The investment will then be a poor one. No matter what price is set during the bidding, only those whose ability is worse than the investor-perceived expected ability of the entrepreneur will sell out. Consequently, the adverse selection problem is so severe that there will never be any selling out. If the entrepreneur is risk averse, then the market may not break down completely. In this case, some entrepreneurs may sell out while others may develop the venture on their own.

We show that, as long as the entrepreneurs are somewhat risk averse and the minimum skill level is not too low, some or all entrepreneurs will sell out. If only some sell out,

² This is the formulation adopted by Chan, Siegel and Thakor (1987).

they will be those with lower skill levels. The investors will still find that, on average, the purchase of the ventures is a zero NPV investment, but the price will be relatively low and the ventures will not be outstanding performers.

To describe the environment with informational asymmetry, we need some further assumptions and notations. Assume that from the perspective of the investors, γ is distributed on some interval $[\underline{\gamma}, \bar{\gamma}]$. Further, assume that $u^*(\underline{\gamma}) \geq U(0)$. Finally,³ we assume that $NPV(w, \gamma)$ is increasing in γ .

Define \bar{w} by $U(\bar{w}) = u^*(\bar{\gamma})$; that is, $\bar{w} \geq 0$ is the amount needed to get the most skillful entrepreneur to sell out. Further, define \underline{w} by $U(\underline{w}) = u^*(\underline{\gamma})$; that is, $\underline{w} \geq 0$ is the amount needed to get the least skillful entrepreneur to sell out. Note that $u^*(\gamma)$ is strictly increasing in γ , so that the entrepreneur with skill level γ will sell out for w if $\gamma \leq u^{*-1}(U(w))$. Let $e(w)$ denote the investor's expectation function:

$$e(w) = E[NPV(w, \gamma) | \text{entrepreneur sells for } w].$$

No entrepreneur will sell out for less than \underline{w} , so the investors' expectation function $e(w)$ for $w \geq \underline{w}$ is given by

$$e(w) = \begin{cases} NPV(w, \underline{\gamma}), & w = \underline{w}, \\ E[NPV(w, \gamma) | \gamma \leq u^{*-1}(U(w))], & \underline{w} < w < \bar{w}, \\ E[NPV(w, \gamma)], & w \geq \bar{w}. \end{cases} \quad (7)$$

Equilibrium in the asymmetric information case is⁴

$$w^* = \text{Max} (w : e(w) = 0). \quad (8)$$

Define γ^* to be such that $u^*(\gamma^*) = U(w^*)$. If $\gamma > \gamma^*$ the entrepreneur will not sell, while if $\gamma < \gamma^*$ the entrepreneur will sell.

PROPOSITION 3. *If the expectation function $e(w)$ is continuous in w , then there exists a bid w^* such that $e(w^*) = 0$, and it is larger than the bid that will yield a zero NPV for the venture with the least skillful entrepreneur, which is larger than the bid needed to get the least skillful entrepreneur to sell out, i.e., $w^* \geq w(\underline{\gamma}) \geq \underline{w}$.*

PROOF. Note that

$$e(w^*(\underline{\gamma})) = E[NPV(w(\underline{\gamma}), \gamma) | u^*(\gamma) \leq U(w(\underline{\gamma}))] \geq NPV(w(\underline{\gamma}), \underline{\gamma}) = 0.$$

Furthermore, if w is very large, $e(w)$ is $E[NPV(w, \gamma)]$, which can be made negative (see Proposition 1). Hence, by continuity of $e(w)$ there exists w^* satisfying $e(w^*) = 0$. Furthermore, $w^* \geq w(\underline{\gamma}) \geq \underline{w}$ (by Proposition 2). Q.E.D.

If $NPV(\underline{w}, \gamma)$ is strictly positive, as will be the case if the entrepreneur is risk averse or if he faces additional costs of obtaining new financing, then w^* will be strictly greater than \underline{w} , and hence γ^* will be strictly greater than $\underline{\gamma}$. That is, the venture capital market does not break down completely in that there will be some interval of entrepreneurs (indexed by their skill level) who will sell out to investors.

The intuitive explanation of why there is not a complete breakdown of the market is as follows. Suppose the investors start out anticipating the worst and bid $w(\underline{\gamma})$. Then they know they will attract entrepreneurs with the lowest skill level, but they also know they will attract risk-averse entrepreneurs with a higher skill level. Thus, they expect positive profits at $w(\underline{\gamma})$ and hence w^* will be set higher in equilibrium.

³ It can be shown that $NPV(w, \gamma)$ is increasing in γ if $f(x; \gamma, a, I) = h(x; g(\gamma, a, I))$ where $g_{aa} \leq 0$ and $g_{a\gamma} \geq 0$.

⁴ There may be several bids w satisfying $E(w) = 0$. We assume that competition will lead to the largest being chosen.

The assumption that the venture is worthwhile even for the least skillful entrepreneur is an important one for showing that some entrepreneurs will sell out. If this is not the case, then (following the formalism above) \underline{w} could be negative as could be w^* . But in this case, entrepreneurs will either quit or continue the venture on their own.

It is logically possible for there to be no market breakdown whatsoever, i.e. $w^* \geq \bar{w}$. This will occur if there is relatively little uncertainty about γ , or if entrepreneurs are very risk averse, or if personal borrowing is very costly for the entrepreneur.

7. Information about Entrepreneurial Ability

In the asymmetric information case we observed that an entrepreneur with ability γ will not sell out if $\gamma > \gamma^*$. Recall that γ^* corresponds to the equilibrium bid w^* . Note that w^* was established in an informational setting in which investors were not able to assess the entrepreneur’s unique ability. The entrepreneur may find it worthwhile to invest in accurate and verifiable information about his skill level if the technology for generating such a signal is available and affordable. We now turn to the question of who will generate a perfectly revealing signal that eliminates information asymmetries and then sell to investors.

We assume that the perfectly revealing signal can be generated at a cost C . It is obvious that an entrepreneur will not plan to generate a signal and then develop the venture alone. Consequently, there are three possibilities: sell without a signal for some amount w^{**} , generate a signal and sell for the resulting competitive bid (which is a function of γ), and develop the venture alone without generating a signal.

If an entrepreneur invests in a signal and sells the venture, he will get utility $U(\hat{w}(\gamma, C))$, where $\hat{w}(\gamma, C)$ is derived below. After seeing the signal, investors know that if they obtain rights to the venture they will solve

$$\begin{aligned} &\text{Maximize } \int (x - s(x))f(x; \gamma, a, I) - I \\ \text{s.t. } &\int U(s(x) - C)f(x; \gamma, a, I) - V(a) \geq U(w - C), \\ &a \text{ maximizes } \int U(s(x) - C)f(x; \gamma, a, I) - V(a). \end{aligned}$$

Define \hat{w} by $\hat{w} = w - C$ and $\hat{s}(x) = s(x) - C$. Then the equivalent problem is

$$\begin{aligned} &\text{Maximize } \int (x - \hat{s}(x))f(x; \gamma, a, I) - I - C \\ \text{s.t. } &\int U(\hat{s}(x))f(x; \gamma, a, I) - V(a) \geq U(\hat{w}), \\ &a \text{ maximizes } \int U(\hat{s}(x))f(x; \gamma, a, I) - V(a). \end{aligned}$$

The maximized net present value is $\text{NPV}(\hat{w}, \gamma) - C$. In equilibrium, \hat{w} will be set so that

$$\hat{w}(\gamma, C) = \max (w: \text{NPV}(w, \gamma) \geq C).$$

Note that $\hat{w}(\gamma, C)$ is increasing in γ .

If an entrepreneur does not generate a signal, but sells out at w^{**} , he will realize utility $U(w^{**})$. The competitive bid, w^{**} , is determined by

$$w^{**} = \text{MAX} \{w: E[\text{NPV}(w, \gamma)|\text{entrepreneur sells for } w \text{ with no signal}] = 0\}. \quad (9)$$

Proof of the existence of $w^{**} \geq w(\gamma)$ is identical to the proof of the existence of w^* .

We first investigate the relation between w^* and w^{**} . Intuitively, if the signal is feasible, then the investors face an additional adverse selection problem. The case of an entrepreneur wishing to sell without a signal may be worse for investors than that of an entrepreneur wishing to sell when a signal is not an option. The proof is in the following proposition.

PROPOSITION 4. *The bid when a signal is not an option, w^* , is not smaller than the bid when a signal is an option, w^{**} ; i.e. $w^* \geq w^{**}$.*

PROOF. Define $M(\gamma) = \text{Max} [U(\hat{w}(\gamma, C)), u^*(\gamma)]$. If an entrepreneur chooses to sell at some w without a signal, it must be that $U(w) \geq M(\gamma)$. Note that for any w the set $\{\gamma: U(w) \geq M(\gamma)\}$ is contained in the set $\{\gamma: U(w) \geq u^*(\gamma)\}$. Since $M(\gamma)$ is increasing in γ , we have that

$$E[\text{NPV}(w, \gamma) | U(w) \geq M(\gamma)] \leq e(w),$$

where $e(w)$ is defined by (7). Since w^* is the largest w such that $e(w)$ is zero, and since if w is very large, $e(w) < 0$, we have that

$$E[\text{NPV}(w, \gamma) | U(w) \geq M(\gamma)] \leq e(w) < 0 \quad \text{for} \quad w > w^*.$$

Thus, $w^{**} \leq w^*$. Q.E.D.

The equilibrium bid w^{**} made when a signal is possible but not offered (as in (9)) can, however, be equal to w^* , the equilibrium bid made when no signal is possible (as in (8)). If an entrepreneur with ability γ^* (recall that we defined γ^* to be such that $u^*(\gamma^*) = U(w^*)$) weakly prefers developing the venture alone to generating the signal and selling, w^* and w^{**} will be equal. Intuitively, if this condition is satisfied, then at w^* , the entrepreneur is indifferent between selling without an entrepreneurial ability signal and developing the venture alone. But this is precisely the condition that determines w^* , and hence w^{**} will equal w^* . Thus we have

COROLLARY 1. *If $u^*(\gamma^*) \geq U(\hat{w}(\gamma^*, C))$, then $w^* = w^{**}$.*

PROOF. From Proposition 4, $w^{**} \leq w^*$. However, under the condition of the corollary,

$$\begin{aligned} E[\text{NPV}(w^*, \gamma) | U(w^*) \geq M(\gamma)] &= E[\text{NPV}(w^*, \gamma) | \gamma \leq M^{-1}(U(w^*))] \\ &= E[\text{NPV}(w^*, \gamma) | \gamma \leq u^{*-1}(U(w^*))] = 0, \end{aligned}$$

since $M(\gamma^*) = u^*(\gamma^*) = U(w^*)$. Q.E.D.

In the setting of Corollary 1, the two bids are the same. However, they are not in general equal. In particular, suppose that the signal is costless. Failure to provide a costless signal tells the investors that the entrepreneur is worse than the average. That is, if a bid is offered so that the entrepreneurs who sell are the ones whose ability is low, then the investors lose money. Thus, the only way they can protect themselves is to make a bid based on the profitability of the least skillful entrepreneur. But if this is the case, then all but the least skillful entrepreneurs will choose to generate a signal.

PROPOSITION 5. *If the cost of the signal is zero, then all entrepreneurs will prefer to generate the signal. That is, $w^{**} = w(\underline{\gamma})$.*

PROOF. If $C = 0$, then $U(\hat{w}(\gamma, C)) = U(w(\gamma)) \geq u^*(\gamma)$. Thus, if $w > w(\underline{\gamma})$,

$$\begin{aligned} E[\text{NPV}(w, \gamma) | U(w) \geq M(\gamma)] &= E[\text{NPV}(w, \gamma) | U(w) \geq U(w(\underline{\gamma}))] \\ &= E[\text{NPV}(w, \gamma) | w \geq w(\underline{\gamma})] \\ &< E[\text{NPV}(w(\underline{\gamma}), \gamma) | w \geq w(\underline{\gamma})] = 0, \end{aligned}$$

by the definition of $w(\underline{\gamma})$. Thus, w^{**} must be equal to $w(\underline{\gamma})$. Q.E.D.

Figure 1 presents various possibilities for the relation between the entrepreneur's utility when a report is generated at some positive cost (i.e., $U(\hat{w}(\gamma, C))$) and the entrepreneur's utility derived from developing the venture alone ($u^*(\gamma)$). The figures illustrate several intuitively appealing results. First, if the signal is very inexpensive, then we would expect the situation to be as depicted in a_1 . In this case, all entrepreneurs sell, but lower skill entrepreneurs do so without signalling their ability. Recall from the above proposition that if the cost is in fact zero, all entrepreneurs will generate the signal. The opposite situation is depicted in b_1 , a case in which the signal is very expensive. This situation is identical to the situation in which generating the signal is impossible.

The remaining illustrations in Figure 1 describe intermediate cases. Note that it is not a general result that high-ability entrepreneurs necessarily generate the signal nor necessarily develop the project alone (compare the cases in a_2 and b_2). In all cases, there is an interval of low-ability entrepreneurs who choose to sell without the signal. The intuitive explanation for this result is the same as that which accounts for the interval of low-ability entrepreneurs who choose to sell out when no ability signal is possible. That is, given the equilibrium price, the utility of such low-ability entrepreneurs exceeds their utility had they chosen to develop the venture alone.⁵

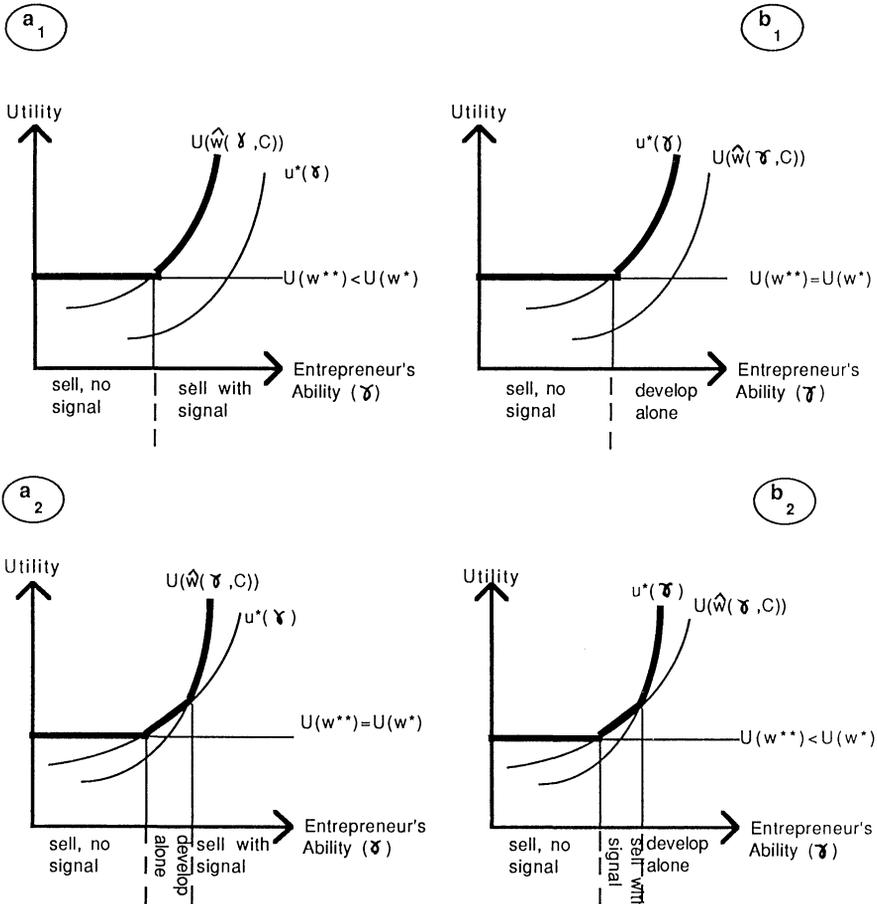


FIGURE 1. The Entrepreneur's Venture Development Choices.

⁵ A detailed example of the asymmetric information case, which illustrates both analytically and graphically the implications of our general results, is available from the authors.

8. Conclusions and Implications

In the analytical model an uncertain payoff from an entrepreneurial venture is assumed to depend on the ability of the entrepreneur, the efforts devoted to developing the venture, and the amount of capital that is invested. In considering the desirability of financing, entrepreneurs—who are assumed to know their abilities—seek to share risk and raise capital. While the entrepreneurs' abilities are a critical determinant of the ultimate payoff from the venture investment, the venture capitalists may be unable to assess accurately this ability when pricing the deal. This raises both moral hazard and adverse selection problems which we addressed by considering three informational settings.

First, we assumed that the entrepreneur's abilities are common knowledge. We found that all risk-averse entrepreneurs choose to involve risk-neutral venture capital investors, since the risk sharing provided by such outside participation dominates the agency relationship that is created. In the second setting we assumed asymmetry of information with respect to the entrepreneur's ability. That is, the entrepreneur knows his skill level while the venture capitalist does not. In this setting we found that because of the adverse selection problem that is created, it is the less profitable ventures—those started by less capable entrepreneurs—that are sold, whereas the more profitable ones are retained by the more skillful entrepreneurs. The investors will still find that, on average, the purchase of such ventures is a zero NPV investment, but the price will be relatively low, and the ventures will not be outstanding performers.

In the third informational setting we assumed that asymmetry of information exists, but that it is possible for the entrepreneur to invest in information that will reveal his skill level. The analysis of this setting suggests that there will always be some selling out by the less skillful entrepreneurs who do not generate a signal about their abilities. Also, we find that the equilibrium price for ventures that are sold without using an available signal will always be less than, or equal to, the price for ventures that are sold to investors when a signal is not possible. The equilibrium prices will be just equal when the cost of generating a signal is so high that not producing it has no informational implications about the ultimate profitability of the venture. We also find that when the signal is costless, all entrepreneurs will choose to produce a signal about their abilities, and the equilibrium price will be the one that yields zero NPV for the least skillful entrepreneur. Additionally, we find that it is not a general result that high-ability entrepreneurs either necessarily generate a signal or necessarily develop the venture alone.

The analysis presented leaves many unanswered theoretical and empirical issues. For instance, one might consider a setting in which a costly signal could be generated to reduce, but not to eliminate, the informational asymmetries about the entrepreneur's abilities. A model with incomplete signals may be particularly interesting in a dynamic setting in which the venture capitalist gradually learns about the entrepreneur's ability. Other theoretical extensions include the formulation and analysis of models that capture additional aspects of the adverse selection problem such as the revelation game, as well as the bargaining issues associated with negotiating the venture capital contract.

Our model helps explain the poor return of venture capital investments as reported by Bygrave et al. (1988). We found that while the equilibrium price paid for new ventures is the one for which the expected NPV equals zero, there will be less skillful entrepreneurs that will receive funding. The implication of this observation is that, to the detriment of entrepreneurs, the resistance of venture capital firms to raise prices paid for new ventures is indeed justified.⁶

⁶ The authors thank Debra Aron, Ravi Jagannathan, Cynthia Montgomery, Don Siegel, Birger Wernerfelt, and seminar participants at the Universities of British Columbia, Chicago, Illinois, Indiana, Michigan, and Pennsylvania, as well as Northwestern, Purdue, Rice, Southern Methodist and Tel-Aviv Universities for helpful suggestions.

Appendix

PROOF OF PROPOSITION 1. Consider $NPV(0, \gamma)$. A feasible contract, investment, and action triple is $s(x) = x - B(I_e)$, I_e, a_e (recall that I_e and a_e are the solutions to the entrepreneur's problem). This triple is feasible since it satisfies the constraints of the investors' problem (3)–(4), respectively:

$$\int U(s(x))f(x; \gamma, a_e, I_e) - V(a_e) = \int U(x - B(I_e))f(x; \gamma, a_e, I_e) - V(a_e) = u^*(\gamma) \geq U(0),$$

and by definition a_e maximizes $\int U(x - B(I_e))f(x; \gamma, a, I_e) - V(a)$. Then,

$$NPV(0, \gamma) \geq \int [x - (x - B(I_e))]f(x; \gamma, a_e, I_e) - I_e = B(I_e) - I_e \geq 0.$$

Let s^0, a^0, I^0 be the first best solution when w is paid, and let $G(w, \gamma)$ be the maximized net present value of the first best problem:

$$\begin{aligned} & \text{Maximize } \int (x - s(x))f(x; \gamma, a, I) - I \\ & \text{s.t.} \\ & \int U(s(x))f(x; \gamma, a, I) - V(a) \geq U(w), \end{aligned}$$

Pointwise maximization implies that $s^0(x)$ must satisfy $\lambda = 1/U'(s^0(x))$ and hence s^0 is constant and positive. Note that from the constrained maximization we obtain

$$G_w(w, \gamma) = \frac{-U'(w)}{U'(s^0)}.$$

In order to satisfy the constraint of the first best problem, $s^0 > w$, and hence, $U'(s^0) < U'(w)$. This, in turn, implies that $G_w(w, \gamma) < -1$. Therefore, when w is large enough, $G(w, \gamma)$ is negative. Since $NPV(w, \gamma) \leq G(w, \gamma)$, $NPV(w, \gamma)$ must be negative for a sufficiently large w . Continuity proves the existence of $w^*(\gamma)$, for which $NPV(w^*(\gamma), \gamma) = 0$. Q.E.D.

References

- BAUMOL, W. J., "Entrepreneurship in Economic Theory," *Amer. Economic Rev.*, 38, 2 (1968), 64–71.
- BRANDT, S. C., *Entrepreneurship: The Ten Commandments for Building a Growth Company*, Addison-Wesley, Reading, MA, 1982.
- BROPHY, D. J., "Venture Capital Research," in D. L. Sexton and R. W. Smilor (Eds.), *The Art and Science of Entrepreneurship*, Ballinger, Cambridge, MA, 1986, 119–143.
- BYGRAVE, W., N. FAST, R. KHOYLIAN, L. VINCENT, AND W. YUE, "Rates of Return on Venture Capital Investing: A Study of 131 Funds," in B. A. Kirchoff, W. A. Long, K. H. Vesper and W. E. Wetzel, Jr. (Eds.), *Frontiers of Entrepreneurship Research*, Babson College, Babson Park, MA, 1988, 275–289.
- CHAN, Y. S., D. SIEGEL AND A. V. THAKOR, "Learning, Corporate Control and Performance Requirements in Venture Capital Contracts," Finance Dept. Working Paper No. 36, J. L. Kellogg Graduate School of Management, Northwestern Univ., Evanston, IL, 1987.
- COOPER, A. C. AND A. V. BRUNO, "Success among High-Technology Firms," *Business Horizons*, (April 1987), 16–23.
- DAY, D. L., "An Empirical Test of Main and Contingent Effects of Relatedness in Corporate Venturing," in B. A. Kirchoff, W. A. Long, K. H. Vesper and W. E. Wetzel, Jr. (Eds.), *Frontiers of Entrepreneurship Research*, Babson College, Babson Park, MA, 1988, 538–541.
- DRUCKER, P. F., *Innovation and Entrepreneurship*, Harper and Row, New York, 1985.
- HARRIS, M. AND A. RAVIV, "Some Results on Incentive Contracts with Applications to Education and Employment, Health Insurance, and Law Enforcement," *Amer. Economic Rev.*, 68 (1978), 20–30.
- HIRAO, Y., "Learning and Incentive Problems in Repeated Partnerships: An Application to Venture Capital Finance," Dept. of Economics Working Paper, Univ. of Pennsylvania, Philadelphia, PA, 1988.
- HOLMSTROM, B., "Moral Hazard and Observability," *Bell J. Economics*, 10, 1 (1979), 74–91.
- KAMIEN, M. I. AND N. L. SCHWARTZ, *Market Structure and Innovation*, Cambridge Univ. Press, Cambridge, MA, 1982.
- KIHLSTROM, R. E. AND J. J. LAFFONT, "A General Equilibrium Entrepreneurship Theory of Firm Formation Based on Risk Aversion," *J. Political Economy*, 87, 4 (1979), 719–748.
- KIRZNER, I. M., *Discovery and the Capitalist Process*, Univ. of Chicago Press, Chicago, 1985.
- LEIBENSTEIN, H., "Entrepreneurship and Development," *Amer. Economic Rev.*, 38, 2 (1968), 72–83.

- LOW, M. B. AND I. C. MACMILLAN, "Entrepreneurship: Past Research and Future Challenges," *J. Management*, 14, 2 (1988), 139-161.
- MACMILLAN, I. C. AND D. L. DAY, "Corporate Venturing into Industrial Markets: Dynamics of Aggressive Entry," *J. Business Venturing*, 2, 1 (1987), 29-40.
- , R. SIEGEL AND P. N. S. NARASIMHA, "Criteria Used by Venture Capitalists to Evaluate New Venture Proposals," *J. Business Venturing*, 1, 1 (1985), 119-128.
- MACMILLAN, I. C., L. ZEMANN AND P. N. S. NARASIMHA, "Criteria Distinguishing Successful from Unsuccessful Ventures in the Venture Screening Process," *J. Business Venturing*, 2, 2 (1987), 123-137.
- RUMELT, R. P., "Theory, Strategy, and Entrepreneurship," in D. J. Teece (Ed.), *The Competitive Challenge: Strategies for Industrial Innovation and Renewal*, Ballinger, Cambridge, MA, 1987, 137-158.
- SCHUMPETER, J. A., *Capitalism, Socialism, and Democracy*, First Ed., Harper and Brothers, New York, 1942.
- TEECE, D. J., *The Competitive Challenge: Strategies for Industrial Innovation and Renewal*, Ballinger, Cambridge, MA, 1987.
- TIMMONS, J. A., *New Venture Creation*, Second Ed., Richard D. Irwin, Homewood, IL, 1985.
- TYEBJEE, T. T. AND A. V. BRUNO, "A Model of Venture Capitalist Investment Activity," *Management Sci.*, 30, 9 (1984), 1051-1066.
- VAN DE VEN, A. H., R. HUDSON AND D. M. SCHROEDER, "Designing New Business Start Ups: Entrepreneurial, Organizational and Ecological Considerations," *J. Management*, 10, 1 (1984), 87-107.