WHY DO VENTURE CAPITAL FIRMS EXIST? THEORY AND CANADIAN EVIDENCE

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EXECUTIVE SUMMARY

This paper investigates the role of venture capitalists. We view their "raison d'être" as their ability to reduce the cost of informational asymmetries. Our theoretical framework focuses on two major forms of asymmetric information: "hidden information" (leading to adverse selection) and "hidden action" (leading to moral hazard). Our theoretical analysis suggests four empirical predictions.

1. *Venture capitalists operate in environments where their relative efficiency in selecting and monitoring investments gives them a comparative advantage over other investors. This suggests strong industry effects in venture capital investments. Venture capitalists should be prominent in industries where informational concerns are important, such as biotechnology, computer software, etc., rather than in "routine" start-ups such as restaurants, retail outlets, etc. The latter are risky, in that returns show high variance, but they are relatively easy to monitor by conventional financial intermediaries.*
2. *Within the class of projects where venture capitalists have an advantage, they will still prefer projects where monitoring and selection costs are relatively low or where the costs of informational asymmetry are less severe. Thus, within a given industry where venture capitalists would be expected to focus, we would also expect venture capitalists to favor firms with some track records over pure start-ups.*

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To clarify the distinction between point 1 and point 2, note that point 1 states that if we look across investors, we will see that venture capitalists will be more concentrated in areas characterized by significant informational asymmetry. Point 2 says that if we look across investment opportunities, venture capitalists will still favor those situations which provide better information (as will all other investors). Thus venture capitalists perceive informational asymmetries as costly, but they perceive them as less costly than do other investors.

3. *If informational asymmetries are important, then the ability of the venture capitalist to "exit" may be significantly affected. Ideally, venture capitalists will sell off their share in the venture after it "goes public" on a stock exchange. If, however, venture investments are made in situations where informational asymmetries are important, it may be difficult to sell shares in a public market where most investors are relatively uninformed. This concern invokes two natural reactions. One is that many "exits" would take place through sales to informed investors, such as to other firms in the same industry or to the venture's own management or owners. A second reaction is that venture capitalists might try to acquire reputations for presenting good quality ventures in public offerings. Therefore, we might expect that the exits that occur in initial public offerings would be drawn from the better-performing ventures.*
4. *Finally, informational asymmetries suggest that owner-managers will perform best when they have a large stake in the venture. Therefore, we can expect entrepreneurial firms in which venture capitalists own a large share to perform less well than other ventures. This is moral hazard problem, as higher values of a venture capitalist's share reduce the incentives of the entrepreneur to provide effort. Nevertheless, it might still be best in a given situation for the venture capitalist to take on a high ownership share, since this might be the only way of getting sufficient financial capital into the firm. However, we would still expect a negative correlation between the venture capital ownership share and firm performance.*

Our empirical examination of Canadian venture capital shows that these predictions are consistent with the data. In particular, there are significant industry effects in the data, with venture capitalists having disproportionate representation in industries that are thought to have high levels of informational asymmetry. Secondly, venture capitalists favor later stage investment to start-up investment. Third, most exit is through "insider" sales, particularly management buyouts, acquisitions by third parties, rather than IPOs. However, IPOs have higher returns than other forms of exit. In addition, the data exhibit the negative relationship between the extent of venture capital ownership and firm performance predicted by our analysis.

INTRODUCTION

In both Canada and the United States, venture capital finance is a significant form of financial intermediation. There is no strict regulatory definition of the venture capital industry, unlike commercial banking or insurance but, generally speaking, venture capital firms provide privately held "entrepreneurial" firms with equity, debt, or hybrid forms of financing, often in conjunction with managerial expertise. In Canada these firms are playing an increasingly important role. As reported in Macdonald & Associates (1996), between the end of 1991 and the end of 1995, the amount of capital under management by Canadian venture capital firms grew from C$3.2 billion (or about $3.8 billion in 1995 dollars) to C$6 billion, implying an annualized real growth rate of about 12% per year. The rate of new investment by venture capital firms grew even more rapidly, rising from C$290 million in 1991 (or C$306 million 1995 dollars) to C$669 million in 1995, which corresponds to real growth of more than 20% per year.

Despite its growing importance, the venture capital industry has received much less academic scrutiny than other parts of the financial sector.[1] This applies both to the-

[1] The venture capital industry is more difficult to study than other financial industries such as banking, insurance, stock markets, etc. Little of the relevant information is in the public domain, since the firms financed by venture capitalists are privately held and therefore do not have the same public reporting requirements as publicly traded

ory and to empirical investigation. At the theoretical level, perhaps the most fundamental question to ask about the venture capital industry is why it exists at all. Why have a set of specialized firms that focus on financing the entrepreneurial sector? Even if there were no dedicated venture capital firms, a combination of commercial banks, investment banks, private investors, and stock exchanges providing the necessary intermediation could still be imagined. In fact, among entrepreneurial firms, most finance is provided by banks and private investors (including family members), and many young entrepreneurial firms "go public" on stock exchanges without first seeking venture capital finance. In seeking to understand venture capital finance, it therefore seems important to ask what exactly is the niche filled by venture capital firms.

The primary objective of this paper is to present a theory explaining the existence of the venture capital industry and investigate the consistency of this theory with empirical observations. Our basic hypothesis is that informational asymmetries are the key to understanding the venture capital industry. Previous papers have focused on the importance of asymmetric information in venture capital markets, and several authors have suggested that a central distinction between venture capitalists and other financial intermediaries is that venture capitalists operate in situations where asymmetric information is particularly significant. In this paper we provide a simple formal model that distinguishes venture capitalists from other potential investors on the basis of their ability to deal with informational asymmetries. This model is also used to draw inferences about how venture capital financing would be expected to work. These predictions are then compared with the actual pattern of venture capital investment in Canada. This link between theory and empirical evidence is the main contribution of the paper.

There are two major forms of informational asymmetry. One type, sometimes referred to as "hidden information," occurs when one party to a transaction knows relevant information that is not known to the other party. For example, an entrepreneur developing a new product may have a much better idea about whether the product will actually work than does the venture capitalist who may finance the venture. The problem arises because the informed party typically has an incentive to misrepresent the information. The entrepreneur, for example, may have an incentive to overstate the likelihood of successful product development. Furthermore, the market may become crowded with "low-quality" projects, precisely because it is hard for investors to distinguish between good-quality and poor-quality projects. This phenomenon is called adverse selection. Potential investors understand that adverse selection exists and may therefore be wary of funding such entrepreneurial endeavours.[2]

The other type of informational asymmetry is often described as "hidden action." In this situation one party to a transaction cannot observe relevant actions taken by the other party (or at last cannot legally verify these actions). For example, an investor in an entrepreneurial firm might not be able to observe whether the entrepreneur is working hard and making sensible decisions, or whether the entrepreneur is planning to "take the money and run." This problem leads to what is called "moral hazard." The

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firms. Also, regulatory scrutiny of the industry is modest compared to other financial services, therefore relatively little information arises from regulatory activities. Finally, as there are no organized exchanges for venture capital investments, no information derives from that source.

[2] A local financial advisor summed up a typical reaction: "You can meet ten enterpreneurs at a party and each one will tell such a good story that you will want to invest your life savings. Remember, however, that you will lose money on at least 7 out of the 10. My policy is never to invest in entrepreneurial ventures."

informed party then has an incentive to act out of self interest, even if such actions impose high costs on the other party.

Both adverse selection and moral hazard may arise in any investment environment, but they seem particularly acute in entrepreneurial finance. With large established firms, investments are made safer by the use of existing assets as collateral, and the development of reputation. Collateral and reputation effects can mitigate the negative effects of both adverse selection and moral hazard. Because entrepreneurial firms lack assets to provide as collateral, and because they lack the "track record" necessary to establish their reputation, the effects of informational market failures are more severe in entrepreneurial finance than in financing established firms.

Our central hypothesis is that venture capitalists emerge because they develop specialized abilities in selecting and monitoring entrepreneurial projects. In other words, venture capitalists are financial intermediaries with a comparative advantage in working in environments where informational asymmetries are important. This is their niche.[3]

The next section of our paper provides a brief review of relevant literature, followed by a section that sets out a formal model of venture capital finance with associated empirical predictions. The fourth section describes the data set obtained from Macdonald & Associates, and the fifth section compares the theoretical predictions with the data. The final section contains concluding remarks.

LITERATURE REVIEW

Akerlof (1970) is normally taken as the starting point of the formal analysis of informational asymmetry. Akerlof describes a situation where sellers of used cars have private information about the quality of their cars, but buyers cannot discern quality differences before purchase. In this setting, low-quality cars or "lemons" dominate the market, thus the market "selects" adversely. Akerlof showed that this adverse selection is inefficient in that potentially efficient (i.e., Pareto-improving) trades will not take place.

Adverse selection problems can arise in many circumstances. For example, in insurance markets, buyers may know their true risk better than insurance companies (as in Pauly (1974)), and in labor markets, workers may be more aware of their abilities than potential employers are (as in Spence (1973)). Spence points out that one natural market response to adverse selection is "signalling," where an informed party (usually the seller of the high-quality item) provides some signal of high quality. Thus, for example, product warranties may be signals of high quality. Rothschild and Stiglitz (1976) emphasize the rolle of screening, under which the uninformed party offers a contract or set of contracts that cause informed parties to self-select into different groups.

Hidden action (and moral hazard) was first discussed in insurance markets, where insured parties can take actions that either decrease or increase the risk of hazard. For example, after purchasing auto insurance, the insured party can either drive safely or dangerously. Early influential work on moral hazard includes Arrow (1973) and Pauly (1974), who showed that moral hazard causes market failure. Moral hazard problems are particularly important in many situations where one party acts as an agent for another party, such as when a client hires a lawyer, or the seller of a house hires a sales agent. In these situations, the "principal" cannot perfectly observe the effort (or other actions) of the agent. Jensen and Meckling (1976) argue that agency relationships are

[3]This analysis focuses on the venture capitalist's role as a buyer of entrepreneurial assets. Venture capitalists must also be good at selling these assets. That is, they must also exit effectively from their investments.

the key to understanding the modern firm. Thus, for example, the managers of the firm can be viewed as the agents of the owners, who might in turn be viewed as the agents of other investors in the firm.

Adverse selection and moral hazard are often viewed as crucial determinants of venture capital financing. Sahlman (1990), for example, postulates that contracting practices in the venture capital industry reflect informational asymmetries between venture capitalists and entrepreneurs, and argues that the lack of operational history aggravates the adverse selection problem. MacIntosh (1994) also asserts the basic idea that informational asymmetries are fundamental in the venture capital sector, and this point is also emphasized in Amit, Glosten, and Muller (1993). Various other papers implicitly recognize the importance of informational issues. For example, MacMillan, Zemann, and Narashima (1987) provide a valuable discussion of how venture capitalists screen new projects.

Chan (1983) highlights the role of venture capitalists in reducing the adverse selection problem in the market for entrepreneurial capital. He shows that an adverse selection result derives from the absence of any informed venture capitalists in the sense that only inferior projects are offered to investors. However, the introduction of informed investors may overcome this problem, leading to a Pareto-preferred solution. Amit, Glosten, and Muller (1990) present an agency model in which investors are uncertain about the entrepreneur's type when submitting investment bids. The authors relate the venture capital financing decision to the entrepreneur's skill level and predict which entrepreneurs will decide to enter into an agreement with venture capitalists.

Sahlman (1990) notes that staged investment, which creates an option to abandon the project, is an important means for venture capitalists to minimize agency costs.[4] The role of staged investment as a monitoring device is also examined by Gompers (1995). In addition, the active involvement of venture capitalists in the operation of their investee companies might mitigate the moral hazard problem. The empirical significance of the role of venture capitalists as monitors is supported by Barry et al. (1990) and by Lerner (1995). In addition, Lerner (1994) suggests the use of syndication (i.e., coordinated investment by two or more venture capitalists) as a method of reducing problems caused by informational asymmetries. Two other useful papers that describe actions that venture capitalists can take to reduce problems arising from informational asymmetries include Tyebjee and Bruno (1984) and Fried and Hisrich (1994).

Chan, Siegel, and Thakor (1990) seek to explain various "rules of thumb" in venture capital contracting practices as a response to informational asymmetries and, in a related paper, Hirao (1993) assumes that the entrepreneur's unobservable actions affect the venture capitalist's learning process, and uses this context to study the effects of different contracts. A more general overview of research challenges in the venture capital area is given by Low and MacMillan (1988).

Despite a number of empirical and descriptive studies on venture capital practices and activities, including some of those already mentioned and also MacMillan, Siegel, and Narashima (1985), Bygrave and Timmons (1992), and Gompers and Lerner (1994), among others, empirical work on venture capital finance is still relatively modest in scope compared to the analysis of other financial intermediaries. Our paper seeks to add to this literature. Specifically, we provide a formal model that uses asymmetric information to explain the existence of venture capitalists, then compare the predictions of this theoretical structure with evidence on venture capital finance in Canada.

[4] Admati and Pfleiderer (1994) and Hellmann (1994) provide formal models of staged finance in the venture capital context.

A THEORY OF VENTURE CAPITAL FINANCE

An entrepreneur has a potential project and seeks potential investors. To keep the analysis simple we assume that the project requires fixed financial input I from an investor. The expected cash flow from the project, net of production costs, is denoted R (for "net operating revenue"). This expected net operating revenue depends in part on the effort, e, provided by the entrepreneur and it depends in part on the underlying project quality, q. In addition, the outcome depends on a random variable, u, with expected value 0. The realized net cash flow is therefore

$$R(e,q) + u \tag{1}$$

where the expected operating revenue is R(e,q). We assume that entrepreneurs and investors are risk-neutral expected value maximizers. We, therefore, ignore u and work with R. Variable u plays one important role, however. Given unobservable random uncertainty, as represented by u, it is not possible for an investor who knows project quality q to infer effort e from the cash flow realization.

If e cannot be observed by the investor, then it is a hidden action and gives rise to a moral hazard (or "agency") problem. If q is known to the entrepreneur, but not to the investor, then it is hidden or private information and gives rise to potential adverse selection. The presence of exogenous uncertainty, as represented by random variable u, does not in itself cause market failure. R is taken to be increasing in e and q. We also assume that there are decreasing marginal returns to effort. The effort effects can be written formally as

$$R_e > 0, \qquad R_{ee} < 0 \tag{2}$$

where subscripts denote (partial) derivatives.

Let the share of the proceeds that go to the investor (possibly a venture capital firm) be denoted α[5]. The expected return V to the investor is

$$V = \alpha R(e,q) - I \tag{3}$$

The expected return to the entrepreneurial firm, denoted π (for "profit"), is its share of the proceeds, net of the costs of effort e.

$$\pi = (1 - \alpha)R(e,q) - e \tag{4}$$

Variable e is normalized so that providing e units of effort imposes cost e on the entrepreneurial firm.

Moral Hazard

To demonsrate the moral hazard problem, assume initially that q is known to both parties. A profit maximizing entrepreneur will maximize (4) with respect to e, leading to the following first order condition:

$$\pi_e = (1 - \alpha)R_e - 1 = 0 \text{ or } R_e = 1/(1 - \alpha) \tag{5}$$

[5] The implied contract has a linear structure. The results in this section are therefore predicated on the assumption of linear contracts. Non-linearities, such as buyback options for entrepreneurs, are not considered here, but might be useful in mitigating some of the addressed informational problems. We thank seminar participants at MIT for pointing this out.

The second order condition for a maximum is $(1 - \alpha)R_{ee} < 0$. Noting that the factor $(1 - \alpha)$ is presumed to be strictly positive and using (2), this second order condition must hold.

The efficient or "first-best" level of effort e* is determined by maximizing the sum of (3) and (4) with respect to e. This sum, denoted S, is

$$S = R(e,q) - I - e. \tag{6}$$

Maximizing (6) with respect to e yields the following first order condition

$$R_e = 1 \tag{7}$$

It follows form (5), (7), and (2) that the entrepreneur will choose less than the efficient level of effort as long as α is strictly positive. This is the moral hazard problem. It is illustrated in Figure A1 in Appendix 1. It follows from the corresponding algebra and Figure A1 that effort is declining in α.

$$de/d\alpha < 0 \tag{8}$$

It is possible that the moral hazard problem might render the project infeasible. The inveestment is attractive to the investor only if the return equals or exceeds the alternative value that can be obtained by investing I elsewhere. Let this required return or opportunity cost be denoted r. Then feasibility requires

$$(1 + r)I \leq \alpha R(e(\alpha),q) \tag{9}$$

The problem is that there may be no value of α that allows (9) to be satisfied. If the expected return to the investor is too low, this suggests raising α, but then e will fall (from (8)), reflecting the idea that the entrepreneur will provide less effort as his stake in the firm falls.

Feasibility for the entrepreneur requires that the expected profit given by (4) exceed the return from the entrepreneur's best alternative, which can be normalized to equal 0. It is possible that effort level e* would in principle allow feasibility for both investor and entrepreneur, but that the actual effort relationship, $e(\alpha)$ would not allow the project to be financed. Thus the moral hazard problem may cause the market to fail.

We now introduce the idea that investors can monitor the entrepreneur and, at some cost, induce the entrepreneur to provide additional effort. Denote the monitoring cost m. The expected return to the investor is therefore

$$V = \alpha R(e(\alpha,m),q) - I - m \tag{10}$$

If the responsiveness of e to m is low, then the investor will not bother to monitor, as the cost will exceed the benefit. Some investments may be worthwhile, without monitoring, in spite of the moral hazard problem, but many projects will be abandoned. If e is highly responsive to monitoring, then the investor will undertake monitoring and will elicit an effort level closer to "first-best" level e*. Projects that are not financed by other investors will be feasible for investors who are good at monitoring (i.e., those for whom the responsiveness of e to m is high).

It is also possible that the investor provides valuable services, s, to investee companies. These services (e.g., providing strategic and operational advice, aid in fundraising, adding reputation, etc.) are observable by the entrepreneur. Ignoring monitoring for the moment and normalizing the cost of providing s to 1 per unit, the expected return to the investor is now

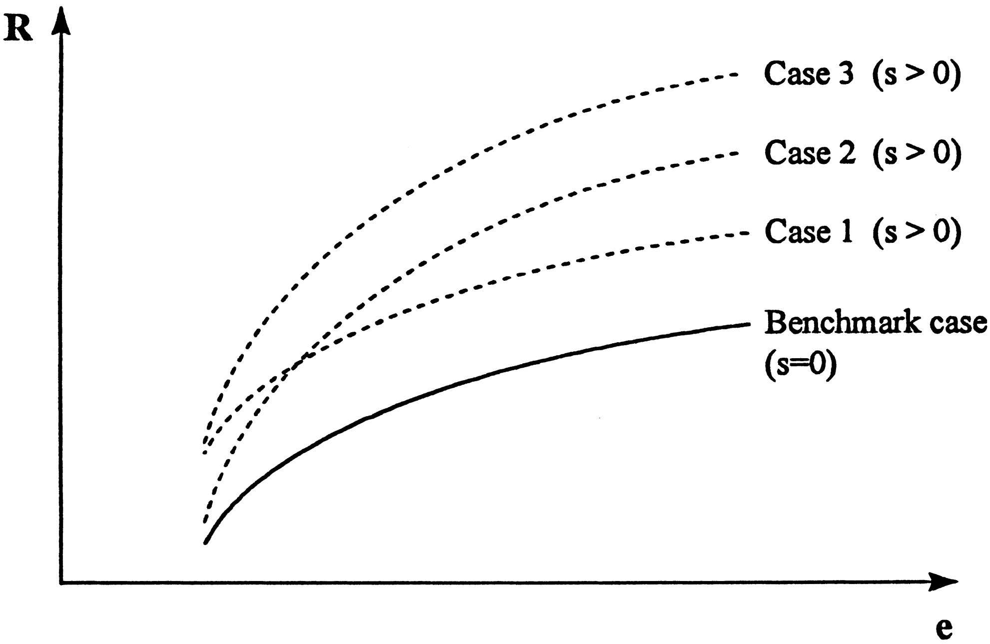

FIGURE 1 Effects of services on expected net revenues.

$$V = \alpha R(e(\alpha),q,s) - I - s \tag{11}$$

We can think of the effect of $s > 0$ on the operating revenues R in the following way. Services s can produce a direct (positive) effect on R through $R_s > 0$ (case 1), or can have an indirect (positive) effect on R through enhancing the marginal productivity of the entrepreneur's effort, or $R_{es} > 0$ (case 2). When both effects are present, $R_s > 0$ and $R_{es} > 0$, we have case 3. Figure 1 illustrates these different cases and compares them with the benchmark case where $s = 0$.

Case 1 is defined as the case in which the investor's provision of s does not affect the entrepreneur's productivity of effort, R_e, but raises revenues directly. Let us assume that this effect is additive. For each effort level e expanded by the entrepreneur, the provision of $s > 0$ by the investor will increase the venture's revenues by ΔR. This is expressed in Figure 1 as a parallel upward shift of the graph of R(e) from the benchmark case to case 1. With respect to the moral hazard problem this means that, relative to the benchmark case, R_e and thus the entrepreneur's incentive constraint (5) remain unchanged in case 1. Therefore our basic analysis for $s = 0$ still holds (see equations (1)–(9) and Appendix 1). In other words, the moral hazard problems in the benchmark case and case 1 are identical.

In cases 2 and 3, however, the provision of s improves the productivity of e, and R_e is consequently shifted upward. This results in steeper curves for cases 2 and 3 in Figure 1. The entrepreneur's incentive constraint (5) is affected by this change, and therefore a new analysis of the moral hazard problem is required. Let us denote the case where $s = 0$ with superscript 0 and cases 2 or 3 where $s = k > 0$ with superscript s. "First-best" effort levels are denoted e^*, "second-best" effort levels e'. The new situation is depicted in Figure 2.

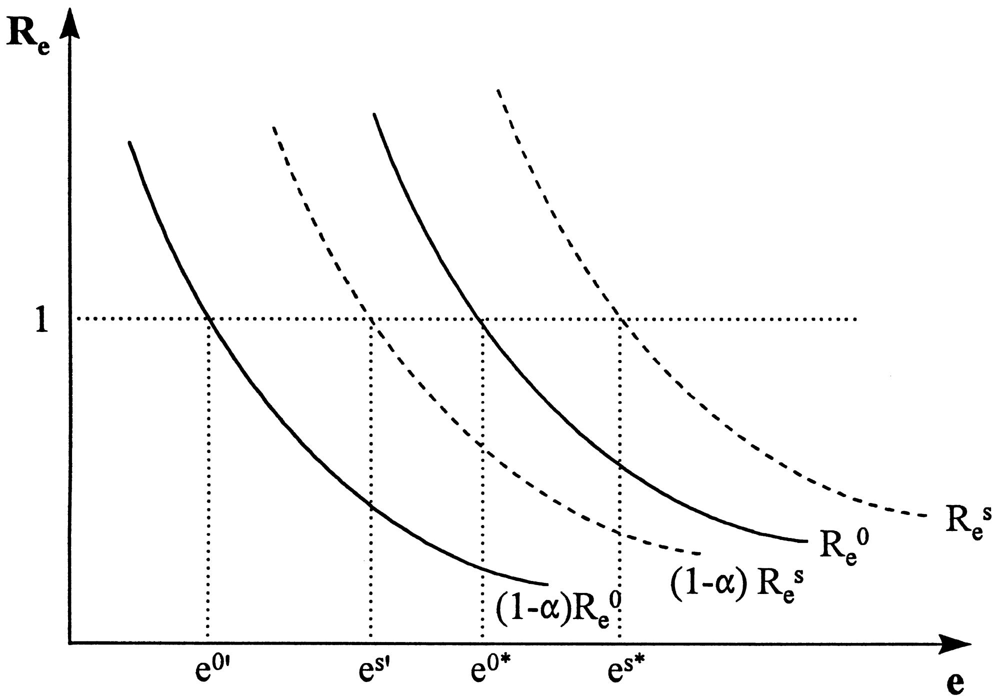

FIGURE 2 First- and second-best effort levels in base case (s = 0) and under $R_{es} > 0$.

Figure 2 is based on the different possibilities of how s can affect R; it also draws on the previous discussion of the standard moral hazard problem (without monitoring or services rendered). It allows us to conclude that the moral hazard problem persists for $s > 0$ even if $R_{es} > 0$. In this case, the "second-best" effort level $e^{s'}$ is still smaller than the "first-best" effort e^{s*}. However, relative to the base case scenario, the entrepreneur is now willing to put forth more effort ($e^{s'} > e^{0'}$).

Thus, the provision of s might contribute to the realization of projects which otherwise would have been abandoned, as they did not fulfill the investor's original feasibility constraint (9). Considering s, the investor's feasibility constraint now becomes

$$(1 + r)\ I + s \leq \alpha R(e(\alpha),q,s) \tag{12}$$

If s is not prohibitively high, then it might relax this constraint through its direct and indirect positive effect on R. Thus, investors who are skilled at providing value-creating services to their portfolio companies will undertake certain projects which other, less skilled investors will shun.

There is ample evidence that venture capitalists provide valuable services to their portfolio companies. Gorman and Sahlman (1989) compiled a list of such services from a survey of venture capital investors. The five highest ranked and most frequently used activities can either be interpreted as directly enhancing investee reveneus (e.g., introduction to potential customers and suppliers, assistance in obtaining additional financing) or as enhancing the entrepreneur's productivity of effort and thus indirectly boosting investee revenues (e.g., strategic planning, management recruitment, operational planning).

We now turn to the case in which both monitoring and services are considered.

The effects of s on R might be important enough to render projects feasible which were infeasible even with optimal monitoring. In fact, it seems natural to assume that a combination of monitoring and the provision of services constitutes a powerful tool in the hands of specialized investors to reduce moral hazard problems. Note, for example, that the entrepreneur's "second-best" effort provided in the case where $s > 0$ and $m > 0$ might be higher than the "first-best" effort in the benchmark case where $s = 0$ and $m = 0$. (Refer to Figure 2 and recall that if e is sufficiently responsive to m, $e^{s'}$ might get fairly cose to e^{s*} under an optimal monitoring regime.)

Another point worth emphasizing is that providing services to entrepreneurs might make it easier and thus cheaper for investors to monitor them. Denoting $M(m|s)$ as the monitoring costs at a given level of s, it is very likely, for example, that $M(m|s > 0) < M(m|s = 0) = m$. Thus, the return to the investor given monitoring and services is

$$V = \alpha R(e(\alpha,m),q,s) - I - s - M(m|s) \tag{13}$$

We note that investors who are good at monitoring and providing valuable services to their portfolio companies are likely to invest in firms with more severe moral hazard problems, as their feasibility constraint is more likely to be fulfilled.

Adverse Selection

A similar pattern emerges when adverse selection is considered. Assume that the venture capitalist chooses the optimal amount of services rendered and the optimal amount of monitoring effort, giving rise to associated values of e and s for any given α. Quality level q is now unobservable to the investor. Suppose that the range of q is such that the average quality project does not yield enough expected returns (for any value of α) to allow both (13) and (4) to be positive. Thus, the average project is *not* worth funding. Formally, we can write the investor's expected return as

$$EV = \int_q [\alpha R(e(\alpha,m(\alpha)),q,s(\alpha)) - I - s(\alpha) - M(m(\alpha)|s(\alpha))]f(q)dq < 0 \tag{14}$$

where f(q) is the probability density function for project quality. To simplify this expression, we subsume the terms that do not bear directly on the analysis of the hidden information problem into investor's costs C. With

$$C = I + s(\alpha) + M(m(\alpha)|s(\alpha)) \tag{15}$$

inequality (14) reduces to

$$EV = \int_q [\alpha R(q) - C]f(q)dq < 0 \tag{16}$$

Inequality (16) says that the expected value across all projects is negative. However, some of the individual projects (those in the upper end of the quality distribution) may be very valuable. Suppose, for example, that the top 40% of projects could generate a positive net profit. Unfortunately, the entire market will normally fail in this situation, as it will typically not be worthwhile for investors to provide financing, even though many individual projects are worthwhile.

Now suppose that an investor can acquire information about the quality of an individual project by spending d before making the actual investment I. Parameter d can be interpreted as the cost of "due diligence." This cost determines the probability, p(d), with which an investor can establish whether the quality of a certain project exceeds a

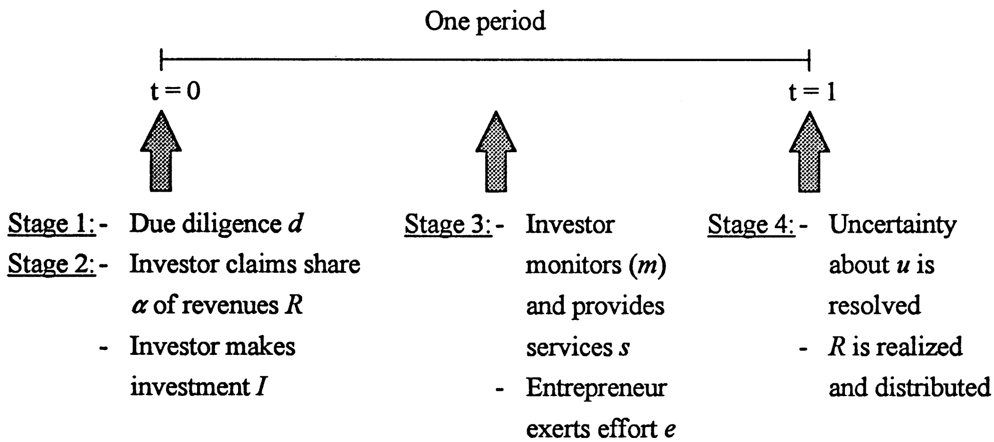

FIGURE 3 Venture capital investment process.

threshold level of quality. We denote this threshold level of quality as q^0. Let us implicitly define q^0 as follows:

$$\begin{aligned} V = \alpha R(q) - C &= 0 \qquad \text{for } q = q^0 \\ V &> 0 \qquad \text{for } q > q^0 \\ V &< 0 \qquad \text{for } q < q^0 \end{aligned} \tag{17}$$

The "detection function" p(d) is assumed to have the following properties:

$$\begin{aligned} &p(d = 0) = 0,\ p(d = \infty) = 1, \\ &p'(d) > 0 \text{ and } p''(d) < 0 \end{aligned} \tag{18}$$

Let us restate the assumptions concerning the sequence of events in the above model. Investment in an entrepreneurial firm is a one period, multi-stage process as illustrated in Figure 3. In the first stage, the investor incurs an up-front cost of d in order to assess the quality of a potential investment. With probability p(d) the investor will become informed about q and will, therefore, find out whether $q \geq q^0$ or $q < q^0$. Only in the former case an investment will be made. With probability $(1 - p(d))$, however, the investor will remain uninformed about q and, due to (16), refrain from investing. Stage 3, in which the entrepreneur displays effort and is monitored and supported by the investor, and stage 4, in which the benefits from the investment are reaped and distributed, occur only if in stage 1 q is found to be greater than q^0.

The expected net return to the investor can therefore be expressed as

$$EV = p(d) \int_{q > q^0} (\alpha R(q) - C) f(q) dq - d \tag{19}$$

Feasibility now requires that

$$r(I + d) \leq EV \tag{20}$$

It follows immediately from (17), (18), and (20) that investors who are good at doing due diligence in the sense that low values of d yield a given value of p are likely to engage in due diligence, select high quality projects (i.e., projects with positive expected return), and make investments.[6] These are the investors that become venture capitalists. (For further formal analysis of the advise selection case, see Appendix 2).

We should emphasize that we assume that the efforts undertaken by the venture capitalist are not subject to free riding. That is, another investor cannot simply observe the venture capitalist who has undertaken diligence and then underbid him. Typically venture capitalists are able to keep the results of diligence and monitoring confidential until after financial contracts have been signed. Free riding does occur but, given the informational asymmetries in the venture capital sector, it seems plausible to abstract from free riding here.

Implications

The above formulation provides the simplest configuration that reflects the idea that venture capitalists are those investors who become skilled at selecting good projects in environments with hidden information and are good at monitoring and advising entrepreneurs who might otherwise be vulnerable to moral hazard problems. The implications of this modeling framework are outlined below.

1. Venture capitalists will operate in environments where their relative efficiency in selecting and monitoring investments and providing value-enhancing services gives them a comparative advantage over other investors. For example, as we have seen in the "hidden action" case, it may take effective monitoring m and specific services s to make a project attractive for an investor. In the "hidden information" case, on the other hand, market failure can be avoided if the probability of detecting whether a project is worth supporting is high enough for sufficiently low due diligence costs. This suggests strong industry effects in venture capital investments. We would expect venture capitalists to be prominent in industries where informational concerns are important, such as biotechnology, computer software, etc., rather than in "routine" start-ups such as restaurants, retail outlets, etc. The latter are risky, in the sense that random variable u has high variance, but they are situations that are relatively easy to monitor by conventional financial intermediaries, whereas the former draw much of their value from idiosyncratic knowledge that is much harder to assess. In principle, in-depth knowledge of traditional industries, such as retailing, is not less advantageous than in-depth knowledge of high-tech industries, but there is some evidence that such wisdom is harder to obtain for knowledge-based industries where informational asymmetries are, therefore, likely to be higher. (See Industry Canada (1994) on the particular difficulties and challenges that investors and lenders face with regard to the assessment of knowledge-based small- and medium-sized enterprises.)
2. Within the class of projects where venture capitalists have an advantage, venture capitalists will still prefer projects where selection, monitoring, and service costs are relatively low or, in other words, where the costs of informational asymmetry are less severe. In the presence of moral hazard, investors would prefer projects for which e is more responsive to m, and/or for which R and/or R_e are more responsive to s.

[6] We acknowledge that the structure of the venture capital investment process as depicted in Figure 3 is a simplification. Venture capitalists make investments even if they are not completely certain that $q > q^0$ and therefore they may earn negative returns on individual investments. However, taking this fact into account does not change the analysis except to add some additional algebra. (Note that in our model expected returns to venture capital investments are positive, but actual returns can be negative if $u < 0$.)

In the presence of adverse selection, projects with a highly responsive p(d) would be favored over those where the detection of quality is more difficult and thus more costly. Thus, within a given industry where venture capitalists would be expected to focus, we would expect venture capitalists to favor firms with some track record over pure start-ups. To clarify the distinction between point 1 and point 2, note that point 1 states that if we look across investors, we will see that venture capitalists will be more concentrated in areas characterized by significant informational asymmetry. Point 2 says that if we look across investment opportunities, venture capitalists will still favor those situations that provide better information (as will all other investors). Thus venture capitalists perceive informational asymmetries as costly, but they perceive them as less costly to deal with than do other investors.

3. If informational asymmetries are important, then the ability of the venture capitalist to "exit" may be significantly affected. Ideally, the venture capitalists might wish to sell off their share in the venture after it "goes public" on a stock exchange. If, however, these investments are made in situations where informational asymmetries are important, it may be difficult to sell shares in a public market where most investors are relatively uninformed. Public investors probably have a less responsive function p(d) and therefore (19) could be negative for them. This concern invokes two natural reactions: One is that many "exits" would take place through sales to informed investors, such as other firms in the same industry as the venture or to the venture's own management or owners. These informed investors probably have similar, if not better detection functions p(d) than the venture capitalist. A second reaction is that venture capitalists might try to acquire reputations for only presenting good quality ventures in public offerings. (However, this is an argument drawing on a multiperiod scenario and would therefore require an extension of our model). Therefore, we might expect that the exits that occur in initial public offerings would be drawn from the better-performing ventures.[7]
4. The model implies that dR/de ($= R_e$) > 0 and $de/d\alpha < 0$. Together these two properties imply $dR/d\alpha < 0$. Other things equal, we can expect entrepreneurial firms in which venture capitalists own a large share to generate lower net returns. This would be due to the moral hazard problem. Higher values of α reduce the incentives of the entrepreneur to provide effort. Nonetheless, it still might be optimal in a given situation for the venture capitalist to take on a high ownership share, as this might be the only way of getting sufficient financial capital into the firm. However, we would still expect a negative correlation between the venture capital ownership share and firm performance.

We note, however, that the model also suggests a negative relationship between R and α for another reason. Specifically, the selection constraint for investors is that $\alpha R \geq (1 + r)I$ or $R \geq (1 + r)I/\alpha$. If the venture capital market were very competitive so that investors earned no rents, then this selection constraint would hold with equality, and there would be an exact negative relationship between expected net operating revenues and α, whether or not moral hazard was present. Even if venture capitalists earn some expected rents, this selection constraint will still rule out combinations of low α and low R, which will tend to induce a negative correlation between R and α. The basic

[7] Empirical work by Megginson and Weiss (1991) and Gompers (1996) is consistent with the idea that the reputation of venture capitalists is very important at the IPO stage.

logic is that, for a given investment I, investors will need to be compensated by a large ownership share α if the expected net operating revenues are relatively low.

THE DATA SET

The data used for this study were collected by Macdonald & Associates Ltd. and made available to us on a confidential and anonymous basis. In addition, no individual firm-specific information is reported or discussed in our analysis. The data are derived from two surveys. The first survey, referred to as the "investment survey," began as an annual survey in 1991 and became quarterly in 1994. It asks just over 100 Canadian venture capital firms to identify their investees and provide some information about each investment and divestiture. Investees are recorded in the database and follow-up information is requested in subsequent surveys. The investment survey asks about the amount and stage of each investment and also seeks information about the venture capitalist's ultimate divestiture of its holdings in each investee.[8]

This survey, which covers the period from 1991 through the first quarter of 1996, seeks to obtain comprehensive information from all Canadian venture capital providers. In an effort to get full information about the investee firms, the survey is sent to venture capital companies (as just noted) and other investors who have investments in the venture-backed investees. However, some relevant venture capital providers may have been overlooked in the survey, and some surveyed venture capitalists may not report all of their investments. Nonetheless, Macdonald & Associates Ltd. estimate that the investment survey identifies 90–95% of the underlying population of Canadian firms supported by Canadian venture capitalists.

The second survey, referred to as the "economic impact" survey, began in 1993 and is conducted annually. It seeks additional information about the investees identified in the investment survey. Thus, economic impact information is sought about each investee that received an investment in or after 1991. Retrospective information is also requested. Suppose, for example, that an investee received an investment in 1991. The venture capitalist making the investment would have received a 1993 economic impact questionnaire asking for information about this investee going back as far as 1987. In many cases not much retrospective information can be provided, but the database contains economic information on a reasonable number of investees going back as far as 1987. The date of the investee's original startup (which in some cases is well before 1987) is also reported.

The response rate for the economic impact survey over its three year life has varied between 56% and 74% (i.e., information has been received on 56% to 74% of the targeted investee firms). If the investment survey identifies 90–95% of the relevant underlying population, then the effective sample coverage is between 50% (.9 times 56%) and 70% of the underlying population. The economic impact survey collects balance sheet and income statement information on the investees (including revenues and taxes paid). It also collects information on the structure and amount of their employment, and the nature of their industry.

A typical investee enters the data set when it receives its first investment from a

[8] This "exit" information, which is obtained on a regular basis from the investment survey, was complemented in November 1995 by an additional survey addressed to venture capital providers who had previously reported on divestitures.

venture capitalist. It may receive investments from additional venture capitalists as well. Subsequent rounds of investment may also occur. Eventually, an investee leaves the sample. This occurs when all venture capitalists have either written off (in the case of failure) or "cash in" their holdings in the investee. Thus, the data set contains a series of "life histories" for venture capital-backed firms.

A "record" refers to information for one particular investee firm for one particular year. There are 387 investee firms in the data availabale from the economic impact survey, but information on about 18 of these firms is significantly incomplete. The remaining 369 firms provide 1,298 reasonably complete records, and, therefore, have an average of about 3.5 records each. The investment survey data includes information on 1,086 Canadian investees. For some purposes, complete matched records are necessary,[9] but much interesting and relevant information is available from just the economic impact data (1,298 records on 369 companies) or just the investment data (2,017 records on 1,086 companies).

These data sets target Canadian investees supported by the Canadian venture capital industry. A Canadian entrepreneurial company that received support exclusively from venture capitalists based in the United States or Asia and had no support from Canadian venture capitalists would not be in our data set. This set of firms is probably fairly small, but there is no data available on its magnitude. It seems unlikely that this omission introduces much systematic bias over most subjects of interest in the data. Despite some possible selection bias in the economic impact data, the data set as a whole remains an important and unique data source.

INVESTMENT PRACTICES OF CANADIAN VENTURE CAPITALISTS

We now present some empirical evidence that addresses the predictions of the theoretical framework outlined in section 3. Some of this data, together with other empirical information on the Canadian venture capital industry is provided by Amit, Brander, and Zott (1997). Before considering the implications of informational asymmetries, we provide a general characterization of important financial variables in the data, as shown in Table 1. All relevant table entries are in thousands of 1995 Canadian dollars. As this table implies, the size of investee companies varies substantially, with a few large firms that make the average values much larger than the median values. The median investee has about 50 Canadian employees and annual revenues of C$6 million. A typical ownership share for the venture capitalist is approximately 30%.

The data in Table 1 also imply that firms in the data set spend, on average, about 3.5% of their revenues on R&D. This is about the same as the overall ratio of R&D spending to revenues for the Canadian economy as a whole. We should note, however, that these rather moderate R&D expenses may be due to different accounting standards that prevail in small and relatively young companies in contrast to large and established firms. Revenues per Canadian employee are $148,800, and the average long term debt to equity ratio is a conservative 0.77. (The long term debt to equity ratios derived from Canadian COMPUSTAT data is estimated to be 1.75 for companies of all sizes, and

[9] Matching the two data bases, we obtain 408 complete records on 302 investee companies. These numbers are low primarily because there are only 339 investee companies with records in both databases and because, for each investee, matches occur only in years when investments were undertaken.

TABLE 1 Summary Financial Data: 1987–94 (in Real $1995)

	Mean ($000s)	Median ($000s)	Standard deviation	No. of records
Total assets	22,928	5,540	70,707	1,277
Total equity	8,777	1,893	25,254	1,274
VC-share of equity (%)	34	30	30	1,218
Retained earnings	848	154	10,098	1,127
Total fixed assets	10,745	1,996	52,353	1,257
Long-term debt	6,729	1,056	28,122	1,157
Revenue	23,657	6,177	56,077	1,290
Investments in property, plant and equipment	1,954	222	8,180	1,161
R&D expenditures	837	79	2,098	1,067
Taxes paid	461	25	1,315	1,027
# of Canadian employees	159	50	301	1,293

Source: Macdonald & Associates Ltd. Economic Impact Database.

0.90 for companies with annual sales less than $100 million.) The low debt-equity ratio may reflect the limited borrowing capacity of entrepreneurial firms. We note also that the average investee is profitable enough to pay nontrivial amounts of tax.

We now consider the implications of the information-based model described in Section 3. One of the implications was that venture capital would be focused on industries where the importance of monitoring and due diligence expertise is particularly great. Table 2 presents information about the industry breakdown of the investee companies, and compares these investment shares with the shares of these industries in total output (as measured by Canadian gross domestic product (GDP)).

TABLE 2 Industry Classification

	Early stage investment* (no. of investees)	Total investment* (no. of investees)	% of early investment	% of total investment	% of total output
Biotechnology	95.4 (43)	121.5 (51)	17	6	0
Communications	83.7 (32)	225.1 (63)	15	10	5
Manufacturing and industrial equipment	78.7 (82)	461.6 (261)	13	21	24
Computer (hardware and software)	70.0 (100)	314.4 (182)	12	14	3
Miscellaneous	67.1 (58)	314.7 (178)	12	15	34
Medical/health	58.4 (34)	176.1 (59)	10	8	3
Energy/environmental technology	57.4 (33)	134.6 (68)	10	6	4
Consumer related	31.7 (27)	296.3 (109)	6	14	26
Electrical components and instruments	25.0 (42)	125 (89)	4	6	2
Total:	567.2** (451)	2169.3 (1060)	99**	100	101**

* In C$ mill; ** Due to rounding. Sources: Macdonald & Associates Ltd. Investment Database. Output shares are based on estimates from Statistics Canada "Gross Domestic Product by Industry," 1996, cat. no. 15-001-XPB.

TABLE 3 Age of Venture-Backed Companies

Year founded	# of companies	% of total
1994	23	6
1993	22	6
1992	20	5
1991	28	7
1984–1990	163	42
1974–1983	85	22
Before 1974	38	12
Total	379	100

Source: Macdonald & Associates Ltd. Economic Impact Database.

As can be seen from Table 2, venture capital is much more heavily represented in biomedical areas, computers, and communications than would be implied by overall output shares of these industries in the economy as a whole. Venture capital has a slightly smaller share of manufacturing and industrial equipment than the economy as a whole, and a much lower share of "consumer related" and "miscellaneous" industries. The main components of these categories are the retail sector and various services. This picture is even more pronounced when only early stage venture capital investments are considered. It seems very plausible that the industries where venture capitalists concentrate the most are those where informational asymmetries are most severe. It is, of course, possible that venture capitalists invest relatively heavily in high-tech industries for reasons unrelated to information. For example, the high-tech sector may simply have a disproportionately large number of new investment opportunities. More specifically, it is a growth sector, and any growth sector will appear to have high levels of new investment from most financial intermediaries, including venture capitalists. Even so, venture capitalists have a heavier relative investment in high-tech industries than other financial intermediaries, and informational reasons offer a plausible explanation for this. Thus, Table 2 is consistent with our theoretical expectations.

The second major implication of the information-based theory developed in Section 3 is that within the sectors where venture capitalists operate, they still prefer to invest in firms where the adverse selection and moral hazard problems are least severe. The following information is consistent with this expectation. First, Table 3 shows the age structure of the investee firms.

As shown on Table 3, quite a few investee companies are surprisingly old. Fully 12% of the 379 companies for whom information on age is available were founded prior to 1974. Since the data set is limited to firms that received at least one infusion of venture capital in 1991 or later, some firms obtain venture capital financing long after being founded. (We note, however, that these firms might have obtained earlier venture capital infusions. Our data suggests that many recorded investments are indeed follow-up investments.)

Furthermore, this information suggests that it takes longer than commonly perceived, and perhaps more venture capital than originally anticipated, to bring some investee firms to the stage at which exit is feasible. A company may be founded well before it obtains its first venture capital investment. These data raise the possibility that venture capital focuses on expansion of existing small companies rather than on the start-up phase. Tables 4 and 5 provide more information on this point.

Table 4 shows how many investments correspond to each stage in the entrepreneurial firm's life. It is based on investment records of investee companies that are in the

TABLE 4 Number of Investments by Stage and Year

	Early stages			Later stages					
	SE	ST	ES	EX	AC	TU	WC	OT	Count
1991	3	100	—	85	12	22	—	36	258
1992	15	111	—	65	23	41	2	50	307
1993	5	116	—	125	18	23	25	37	349
1994	3	128	11	206	12	23	—	15	398
1995	8	130	112	241	11	21	2	44	569
1996(Q1)	5	42	12	54	3	11	—	9	136
Total	39	627	135	776	79	141	29	191	2017

Key: SE = seed; ST = start-up; ES = other early stage investments; EX = expansion; AC = acquisition; TU = turnaround; WC = working capital; and OT = other. Source: Macdonald & Associates Ltd. Investment Database.

Investment Database and includes investments made betwen 1991 and the first quarter of 1996. A given investee may obtain financing from multiple venture capitalists, and may also receive multiple rounds of investment from a given venture capitalist. Each investment, which may include debt, equity, or both, is recorded separately. We observe that a full 60% of the investments made over the period covered by our sample are late stage investments. As early stage investments are both smaller (from Table 5) and less numerous (Table 4) than late stage investments, we can infer that the venture capital industry seems to focus more on growth and development of firms than on start-up activity. Tables 3 to 5 show that venture capitalists focus on firms with a long enough track record to provide significant information about the underlying quality of the venture. Pure start-up activity, where adverse selection and moral hazard problems are most severe, is less significant than later stage investment.

Figure 4 depicts the relative importance of debt and equity in an average or representative investment by stage. There are, for example, 39 seed investments in total. The total equity in these 39 investments is \$21.89 million, giving an average of \$561,000, while the total debt is \$2.34 million, resulting in an average of only \$60,000 (note that most seed investments have no debt). Figure 4 shows that equity is relatively more important at the early stages, and debt becomes more significant later, although equity remains more important in abolute terms for every stage except working capital.

The third major implication of our information-based approach is that we might expect exit to be dominated by "insider" activity rather than by public offerings. Figure 5 shows the pattern of exits in the data and indicates that only about 16% of exits occur after initial public offerings (IPOs). About 10% are third party acquisitions, often by

TABLE 5 Average Size of Investments by Stage and Year (in C\$000's)

	Early stages			Later stages					
	SE	ST	ES	EX	AC	TU	WC	OT	Total
1991	489	678	—	1165	2003	1424	—	1374	1058
1992	900	617	—	1104	1283	628	480	1480	925
1993	836	1101	—	1714	1665	1620	362	1662	1394
1994	425	677	854	1227	2338	1521	—	2391	1128
1995	414	688	1005	1300	2341	436	1378	1564	1098
1996(Q1)	101	1034	847	1297	2260	1601	—	890	1151
1991–96	621	771	997	1316	1824	1107	378	1559	1127

Source: Macdonald & Associates Ltd. Investment Database.

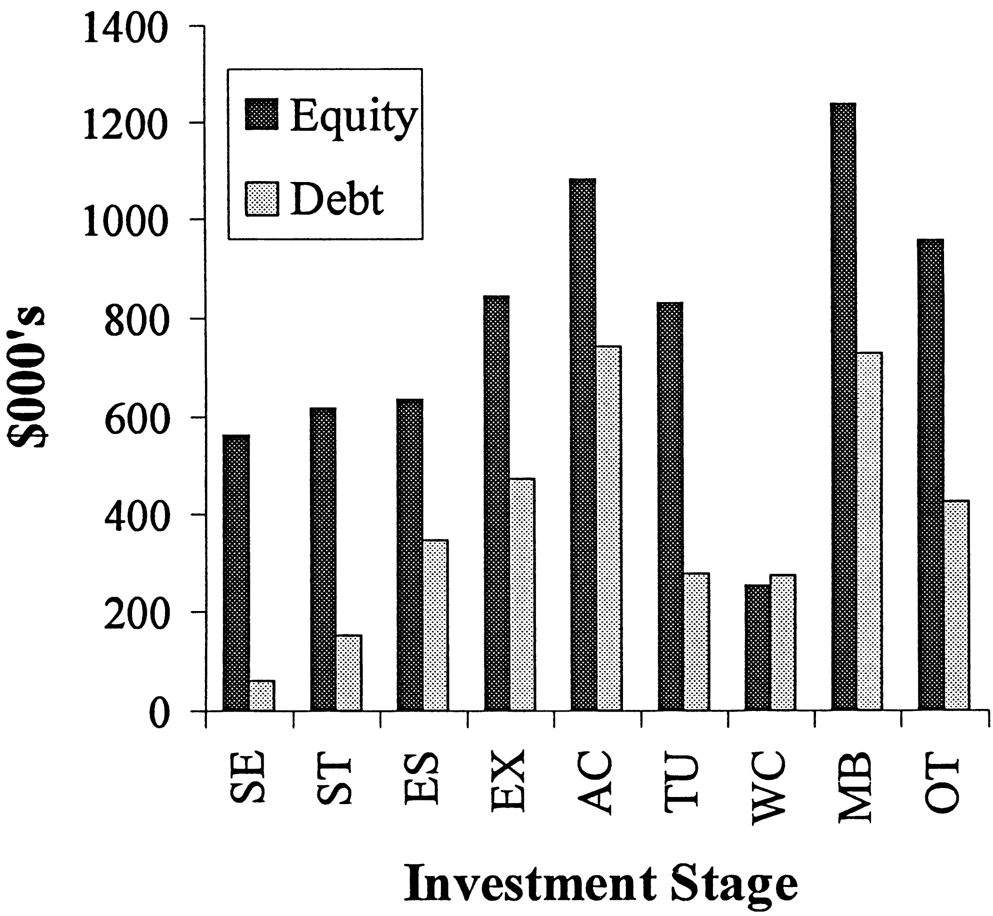

FIGURE 4 Average debt and equity by investment stage 1991–1996(Q1).

a firm in the same industry as the venture. The largest category of exit is company buyouts, in which the venture capitalist's holding is sold to officers or managers of the investee. Fully 37% of exits are in this category. Secondary purchases are purchases of the venture capitalist's holding by a third party in a private transaction that is not an overall acquisition. The "other" category consists of exits for which the exit mode was not identified, but we believe that most of these are company buyouts. Approximately 17% of exits were in the "write-off" category. If informational asymmetries are important, it is not surprising that IPOs account for only a small share of exits while company buyouts are much more important. We wish to note, however, that the small share of IPOs may also partly reflect a minimum scale necessary to sustain a public market in a stock.

Our theoretical framework also suggests that returns would differ by exit vehicle and that, in particular, IPOs would have high returns precisely because venture capitalists seek to reduce the adverse selection problem confronted by buyers of IPOs by only "going public" with relatively strong investee firms. These returns shown in Table 6 are consistent with our expectations. Write-offs, of course, represent a 100% loss over the holding period. Among the other forms of exit, IPOs are relatively profitable. Secondary

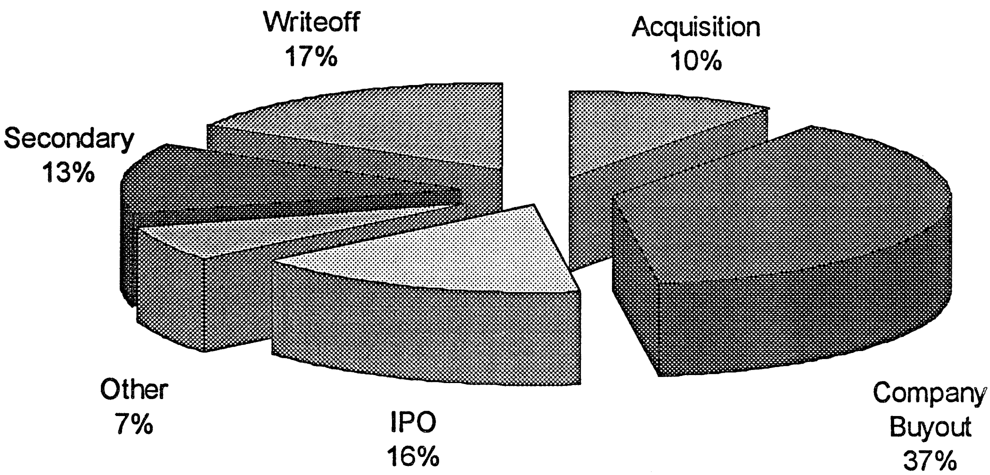

FIGURE 5 Distribution of venture capital exits (percentage of exits).

purchases (i.e., secondary sales from the exiting venture capitalist's point of view) are similarly profitable in aggregate, although with only 11 observations, it is difficult to regard the return to secondary purchases as highly meaningful. In any case, the high return to IPOs is consistent with our expectations.

The final prediction of our model is that the venture capitalist's ownership share should be negatively associated with the firm's performance. This derives both from moral hazard and the venture capitalist's participation constraint that expected returns should at least equal the return from alternative investments. In addition, it is possible that a negative correlation between a venture capitalist's ownership share α and a measure of firm performance could arise from dilution in a multi-period process (i.e., the possibility that low performance leads to high α). Unfortunately, we do not have adequate data, such as data on a venture capitalist's ownership share in the start-up phase, to correct for dilution.

It is difficult to measure firm performance directly, but revenues per unit asset and taxes paid should both be good measures of performance. Table 7 reports the results

TABLE 6 Estimated Real Annual Returns by Exit Type

	Mean of individual real annual returns*	Standard deviation of individual returns	No. of observations	Real annual return of sum of investments**
IPO	43%	62%	26	26%
Acquisition	36%	61%	16	9
Secondary purchase	23%	41%	11	29%
Company buyout	2%	15%	37	0%
Writeoff	100% loss over holding period	—	24	100% loss over holding period
Other	2%	18%	7	13%

* Individual annual returns are calculated as: {(Proceeds from investment − cost of investment) ^ (1/holding period) − 1}. ** This number is calculated as: {(Sum of proceeds from investment − sum of costs of investment) ^ (1/average holding period) − 1}. Source: Macdonald & Associates Ltd. Investment Database.

TABLE 7 Effect of Venture Capital Share on Performance (Tobit Regressions)

Dependent vbl.	Expl. variable	Coefficient	Std. error	T-stat	P-value
TaxesPaid	VCshare	−10.59	1.95	−5.44	.000
	log(Age)	454	61	7.44	.000
	Const.	−696	155	−4.50	.000
TaxesPaid/Assets	VCshare	−28.27	5.94	−4.76	.000
(×10000)	log(Age)	488	187	2.61	.009
	Const.	−578	474	−1.22	.223
Revenues/Assets	VCshare	−46	20	−2.30	.021
(×1000)	log(Age)	−386	649	−0.60	.55
	Const.	8958	1604	5.59	.000

Source: Macdonald & Associates Ltd. Economic Impact Database.

arising from regressing these measures of firm performance on the venture capital ownership share, correcting for age of the firm.

As can be seen from these regressions, there is a statistically strong negative relationship between the venture capitalist's ownership share and these measures of firm performance. Ideally, we would like to use profit as a measure of success, but profit is not available in the data. However, profit is closely related to taxes paid, so taxes should normally be a good proxy for profit. We acknowledge, however, that for emerging growth companies, taxes paid may be a poor preditor of their value creation potential. Note that taxes are truncated from below at 0. (Firms do not pay negative taxes no matter how poor their performance.) Accordingly the estimation is done using Tobit estimation rather than ordinary least squares. The basic finding is that there is a strong negative relationship between whatever measure of performance we use and the share of the venture owned by the venture capitalist. This could be the result of either the moral hazard or the venture capitalist's self-selection constraint. It is also possible that ventures for which α is high pay out more earnings to the venture capitalist, and, therefore, have lower future earnings. However, normalizing for asset size should mitigate this concern.

We emphasize that the amount of variation explained by the venture capital share is low. Thus, while the coefficient on the venture capital share is significant, variations in this share are, at most, a minor determinant of performance. It is also important that these results not be interpreted as suggesting that venture capital investment should be viewed as a negative influence, or that other sources of finance are better than venture capital. Venture capital investments could be an imortant positive influence on every firm in the data set, and could be the best source of financial capital available, and we would still expect to observe a negative correlation between venture capital ownership and performance. What the negative correlation tells us is that the best performing companies tend to be those in which the venture capital ownership share is not too high. However, if financial requirements are high and the owner's sources are meagre, then a substantial venture capital share might be the best option, even if there is an associated moral hazard problem, as the alternative might be outright failure of the company.

CONCLUDING REMARKS

The theoretical framework we offer focuses on informational issues. Specifically, we view asymmetric information as the central feature of venture capital investment. Both major forms of asymmetric information, "hidden information" (leading to adverse selection) and "hidden action" (leading to moral hazard) are included in our analysis. While the model abstracts from some important elements of the venture investment process (such as bargaining, syndication, etc.), we believe that the informational issues are perhaps the most central issues to focus on at this stage.

We have shown that this information-based approach is consistent with the data on Canadian venture capital investments. Moral hazard and adverse selection create a market failure in entrepreneurial financing, which might lead many worthwhile projects to be unfunded or underfunded. The more skilled the venture capitalist is in reducing these sources of market failure, the more effectively this sector will function. Venture capitalists exist because they are better at this function than unspecialized investors. However, venture capitalists cannot eliminate adverse selection and moral hazard. Furthermore, these problems are more acute for younger firms, and most acute for start-ups. This explains why venture capitalists focus on later stage entrepreneurial firms. Later stage firms have a track record that provides information to the entrepreneur, and they have enough assets to reduce the problem associated with limited collateral under limited liability. By virtue of their expertise, venture capitalists are better at dealing with informational problems than are other investors (on average), but this advantage shows up most in later stage entrepreneurial firms rather than at the start-up stage.

This theoretical structure is also consistent with the pattern of exit. If asymmetric information is important, and remains important even at the exit stage, then outside public investors will not be in the best position to evaluate the assets of the entrepreneurial firm, and insiders will be in a better situation to buy out the venture capitalist's position. These insiders might be management or officers of the investee, or they might be other firms in a related business. Thus, it is not surprising that IPOs account for only a modest fraction of exit. In addition, our model predicts a negative relationship between the extent of venture capital ownership and firm performance. This relationship is found in the data.

There are several natural extensions to the line of reasoning presented in the paper. One complicating factor is the possibility that a venture capitalist's cost of monitoring an entrepreneur might vary with the venture capitalist's ownership share. It is sometimes suggested that it is easier for the venture capital firm to monitor if it has a larger ownership share. In our model, this would suggest that m would exogenously depend on α. Furthermore, we recognize that many aspects of venture capital activity have not been captured in our analysis. In particular, we abstract from staged investment, which is a common feature in venture capital finance and can serve to ameliorate problems caused by asymmetric information. It would be interesting to extend our model to a multi-period analysis.

The challenge we and other researchers face is to develop theoretical structures that can be subject to empirical investigation. Ideally such theories should also provide normative implications for practice. Our paper is a small but hopefully useful step in this direction.

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APPENDIX 1

Illustration of the Basic Moral Hazard Problem

Figure A1 shows the marginal cost of effort (a horizontal line) and the marginal expected benefit of effort (given by R_e). The efficient amount of effort occurs where marginal benefit equals marginal cost, and is denoted e* in the diagram. The marginal benefit perceived by the entrepreneur is only $(1 - \alpha)R_e$, which is strictly below R_e. It follows that the amount of effort actually chosen, denoted e', is less than the efficient amount. The basic problem is that the entrepreneur cannot precommit to provide effort level e*. Once financing is obtained and share α of the firm has been sold to the investor, the entrepreneur will only provide effort level e'. If the investor and the entrepreneur could contract over e, then they could agree that e* would be provided, but this is impossible under the assumption that e cannot be observed (or at least legally verified) by the investor.

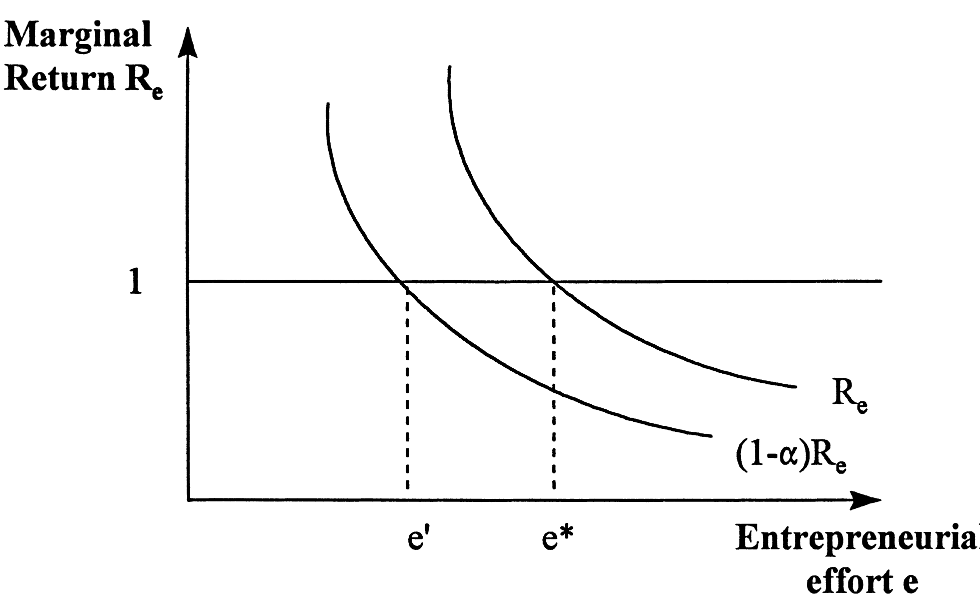

FIGURE A1 Moral hazard.

APPENDIX 2

Formal Analysis of the Adverse Selection Problem

From (18) we derive the first-order condition

$$EV_d = p'(d) \int_{q^0}^{\infty} (\alpha R(q) - C)f(q)dq - 1 = 0 \tag{A2.1}$$

where F is the cumulative distribution of q. Let

$$K = \int_{q^0}^{\infty} (\alpha R(q) - C)f(q)dq \tag{A2.2}$$

Then (A2.1) simplifies to

$$p'(d) = \frac{1}{K} \tag{A2.3}$$

To derive the second-order condition, EV_d is differentiated with respect to d, yielding

$$\begin{aligned} EV_{dd} &= p''(d) \int_{q^0}^{\infty} (\alpha R(q) - C)f(q)dq \\ &= p''(d)\, K \end{aligned} \tag{A2.4}$$

It follows from (17) and (18) that (A2.4) is strictly negative, which is the precondition for (A2.3) to yield a maximum.

(A2.3) has interesting implications. Suppose that R(q) is such that there are many worthwhile projects and a few projects that have very low negative expected returns. q^0 is therefore low. Specifically, assume that K is relatively large, resulting in a rather low value of $p'(d)$, which in term implies a relatively large optimal value of d (if a solution to (A2.3) exists at all). Thus, with such a constellation of parameters, it pays to invest high d in due diligence. On the other hand, if R(q) is such that K is relatively small (which may happen if there are only few attractive projects and many 'lemons,' i.e., if q^0 is high), this will result in a relatively small optimal value of d (depending, of course, on the shape of p(d)).

In order to illustrate the point that an investor with a highly responsive detection function p(d) (say, investor h with a detection function $p(d^h)$) is more likely to invest in projects with high asymmetry of information than an investor with a less responsive p(d) (say, investor l with a detection function $p(d^l)$), let us consider the following case. Assume that q^0 is high and K is small, resulting, according to (A2.3), in a large $p''(d)$. This is fairly realistic, as the pattern of returns of venture capitalists is usually skewed with most investments generating either disappointing or negative returns and only a few becoming 'stars'.

It may happen that investor h finds it worthwhile to spend $d^{h*} > 0$ (which is the value of d^h that satisfies A2.3) and go ahead with project $q \geq q^0$, while investor l finds that the optimal value of d^l is $d^{l*} = 0$ and thus refrains from investing. (Of course, even if $d^{h*} > 0$, the investor's feasibility constraint (20) has to hold before investment I is made.) These points are illustrated in Figure A2.

Note that for some values of K, both d^{l*} and d^{h*} can be positive in our example. Then it pays even for investor l to do due diligence. Again, it also depends on constraint (20) whether either investor l or h or both find the investment attractive.

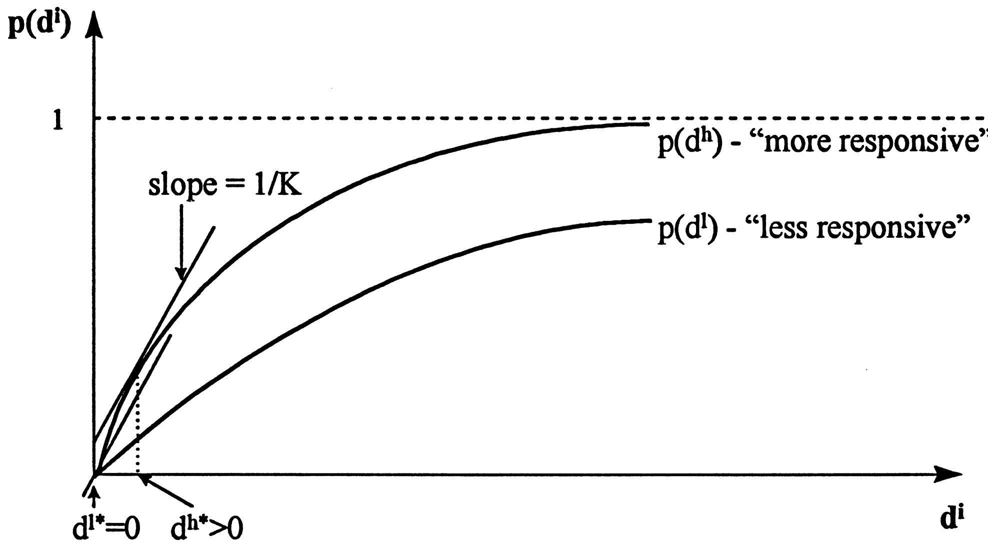

FIGURE A2 Optimal due diligence for different detection functions p(d).