JOURNAL OF FINANCIAL AND QUANTITATIVE ANALYSIS Vol. 46, No. 2, Apr. 2011, pp. 431–457
COPYRIGHT 2011, MICHAEL G. FOSTER SCHOOL OF BUSINESS, UNIVERSITY OF WASHINGTON, SEATTLE, WA 98195
doi:10.1017/S0022109010000840

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

VC Funds: Aging Brings Myopia

Eugene Kandel, Dima Leshchinskii, and Harry Yuklea*

Abstract

We study the conflict of interests between the limited partners (LPs) and the general partner (GP) in a venture capital (VC) fund with a limited life span. LPs commit money, while the GP selects and monitors projects. Midway into the project, the GP privately observes the project's quality and the estimated time to exit. The fund's limited time horizon and the GP's informational advantage lead to inefficient decisions at this stage. First, the GP continues bad projects. Second, he may stop monitoring good, but delay-prone projects. We provide empirical predictions and illustrative evidence that the magnitude of the effect is significant.

I. Introduction

While accounting for a relatively modest part of overall corporate investments, venture capital (VC) investments play the dominant role in financing high-risk, high-return projects, some of which later become the leading firms in the economy. VC funds are the financial intermediaries that invest in firms on behalf of their investors. This creates 2 sets of agency problems: between the VC fund managers and entrepreneurs on the one hand, and between the investors (limited partners (LPs)) and the managers (general partners (GPs)) on the other.

*Kandel, mskandel@mscc.huji.ac.il, Department of Economics and Business School, Hebrew University of Jerusalem, Mount Scopus, Jerusalem 91905, Israel; Leshchinskii, leshchinskii@yahoo.com, Menlo College, 1000 El Camino Real, Atherton, CA 94027; and Yuklea, harryy@mscc.huji.ac.il, Business School, Hebrew University of Jerusalem, Mount Scopus, Jerusalem 91905, Israel. We thank an anonymous referee, Hendrik Bessembinder (the editor), as well as Zeev Binman, Patrick Bolton, Guido Friebel, Dennis Gromb, Ulrich Hege, Thomas Hellmann, Josh Lerner, Moshe Levin, Stefano Lovo, Ludo Phallipou, Leopold Sogner, Eli Talmor, Isabel Tkatch, Flavio Toxvaerd, Moti Weiss, and participants at the 2nd Risk Capital and the Financing of European Innovative Firms (RICAFE) conference, the Vienna Symposium on Asset Management, the European Finance Association conference, and seminars at the Rensselaer Polytechnic Institute, the Norwegian School of Economics, and the University of Amsterdam for very useful comments and suggestions. We thank Michael Borns for his expert editorial assistance. We acknowledge financing from the European Commission, grant HPSE-CT-2002-00140. Kandel and Yuklea also acknowledge financial support under the Science, Technology, and Economy program of the Neaman Institute. Kandel acknowledges the support of the Krueger Center for Finance Research at the Hebrew University.

The former has been extensively studied,[1] while the latter has received much less attention.[2]

In this paper we study the LP-GP agency problem: In particular, we focus on the suboptimal (relative to the first-best) investment decisions by the GP during the life of portfolio firms that may stem from the limited life of the VC funds. According to Gompers and Lerner (1996), since the early 1980s the majority of VC organizations have been structured as limited partnerships; by 1992 they accounted for more than 80% of all VC funds. All such partnerships are mandated to have a limited life span; a typical contract stipulates 10 years, with a possible extension of 1–3 years.[3] Sahlman (1990) and Gompers and Lerner (1996), (2001) recognize that this feature is a part of the contract aimed at reducing the ability of the GP to hold up the LPs once the latter have committed to invest.[4] While this contractual provision is accepted as the industry standard, to the best of our knowledge no previous academic literature has explored its costs.[5] These potentially high costs are the focus of this paper.

Prior to the intermediate financing stage the GP obtains information about the quality of the project and its expected time to exit. The overall first-best decision is to terminate bad projects immediately, while continuing to finance and monitor good projects, regardless of their exit time. The finite life span of the fund forces the GP to sell all the unfinished projects at the fund's maturity, which means that some good projects are sold unfinished. We show that unless the probability of the market learning the true quality of the projects is sufficiently high, the first-best outcome is not attainable under most realistic scenarios. This is because the GP may prefer to continue bad projects and sell them as unfinished good ones (as long as the buyers cannot distinguish between them for sure). In addition, if not sufficiently compensated, the GP does not monitor good but delay-prone projects, which destroys their chances for success. This second type of "myopia" exists

[1]The following list represents only a small sample: Sahlman (1990), Admati and Pfleiderer (1994), Gompers (1995), Lerner (1995), Bergemann and Hege (1998), Hellmann (1998), (2002), Repullo and Suarez (2004), Neher (1999), Kaplan and Stromberg (2003), (2004), Casamatta (2003), Cumming and MacIntosh (2003), Casamatta and Haritchabalet (2003), and Malherbe (2004).

[2]Notable exceptions are Gompers (1996), Gompers and Lerner (1996), (1999), Lerner and Schoar (2004), Litvak (2004), and Phalippou (2007), who study partnership agreements in VC partnerships and private equity funds, and Aghion, Bolton, and Tirole (2004), who study theoretically optimal design of exit options for active monitors (GPs). Glode and Green (2008) and Hochberg, Ljungqvist, and Vissing-Jorgensen (2008) propose models of learning by LPs in VC and private equity partnerships.

[3]These results are consistent with the VentureXpert data. Figure 1 shows the histogram of age at liquidation for all 675 VC funds in the VentureXpert database for which the liquidation time is reported. The average age at liquidation is 13.15 years.

[4]In the corporate finance literature a similar rationale is behind the requirement for a shorter debt maturity (see a recent survey by Benmelech (2009)): Large ex post hold-up potential leads to shorter debt maturity. Similar mechanisms are used in solving ex post renegotiations, and soft-budget constraints problems. As Dewatripont and Maskin (1995) describe it, in order to preclude informed entrepreneurs from undertaking ex ante poor projects, investors have to commit to terminate these projects even if they become good and ex post it is efficient to continue them. They provide an example of decentralized credit as one such commitment mechanism, while bureaucracy is another (see Qian and Xu (1998)).

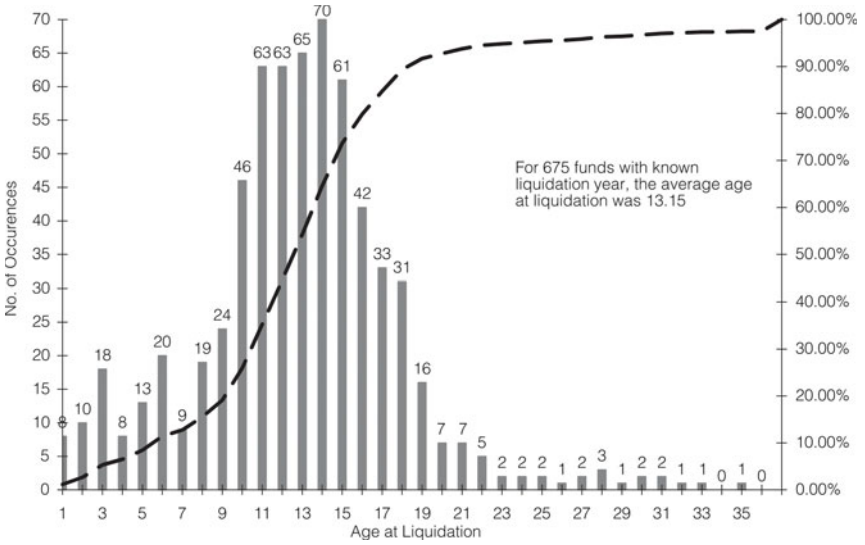
[5]We argue later that while limited liability partnership is widely used in other fields (private equity, oil exploration, real estate, etc.), the problem we discuss is likely to manifest itself to a much greater extent in the case of VC.

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

FIGURE 1

The Histogram of Age at Funds' Liquidation

Figure 1 shows the histogram of age at liquidation for all 675 VC funds in the VentureXpert database for which the liquidation time is reported. The average age at liquidation is 13.15.



independently of the first type. Notice that the previous myopia and the associated costs do not mean that the contractual provision of a limited life span of VC funds is overall suboptimal. It may well be that the benefits outweigh the costs. Nevertheless, we do claim that there seems to be evidence that these costs were not sufficiently understood by academics and practitioners until the 2000 crash brought these costs to their attention.

We present several empirical implications that are based on the result that the fund's age (time to termination) should have a strong effect on the investment decisions and project choices. While the emphasis of this paper is on theoretical arguments, we do provide some empirical evidence on the extent of the problem. We argue that the misalignment of the GP's and the LPs' incentives (and consequently, the loss of efficiency) increased following the NASDAQ decline in 2000 due to structural changes in parameters influencing the GP's behavior. After the crash the existing projects unexpectedly became more delay-prone; thus, if these inefficiencies exist, they should be easier to detect. According to industry reports, the average number of discontinued projects in the post-2000 period reached 30%–60% of the overall number of exits, which is almost double the rate compared to earlier periods. Industry sources suggest that *around 50% of the terminated projects are potentially "good" projects*. We show that after 2000, older VC funds were indeed significantly more likely to abandon good projects than were younger funds. We do not find a similar relation for the corporate VC funds that have no life span limit. Neither do we find this effect in the pre-2000 period in VC funds. Moreover, only high-tech firms seem to exhibit this effect, which is consistent with the large information asymmetry in the high-tech firms. While

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

this is not conclusive evidence, it is clearly consistent with the predictions of the model and opens possibilities for future empirical study.

Our interviews with VC practitioners suggest that these costs were not a major concern in the industry prior to 2000, and only started to surface after the crash, which brought this problem to their attention. Given the amount of funds committed by investors to these financial partnerships (over $180 billion at its peak in 2000), this inefficiency translates into an annual loss of billions of dollars, most of which is borne by the LPs. We present no evidence on the inefficient continuation, but that problem may be of significant magnitude as well.[6] The paper suggests some ways to potentially alleviate these problems, which may be especially important for countries where the VC industry is still developing its contractual arrangements.

The rest of the paper is organized as follows. Section II describes the structure and organization of VC funds and identifies the nature of the problem. Section III presents the model, the first-best outcome, and the main results. Section IV discusses various extensions of the model as well as possible contractual provisions to reduce the costs associated with the myopia. Section V presents the empirical predictions and the evidence. Section VI concludes.

II. VC Fund Structure and Organization

VC investors have experimented with different organizational forms:[7] publicly traded companies, such as Thermo-Electron; publicly traded closed-end funds, such as the American Research and Development Corporation; and, of course, limited partnerships. The latter organizational form came from oil exploration and real estate. Over time, limited partnerships have become a dominant form of VC financing, and by the late 1990s over 80% of the capital committed to venture funds went to limited partnerships (Gompers and Lerner (1999)). Our paper focuses exclusively on limited partnerships.

There are 2 types of partners in a limited partnership: several LPs and 1 GP. LPs commit to deliver a prespecified amount of investment in the fund whenever the GP "calls for money," and in return receive a share of the fund's profits. LPs are legally prevented from being actively involved in the fund's operation. The GP manages the ordinary day-to-day activities of the fund, that is, identifies and invests in projects according to the charter of the fund, executes "due diligence," performs all the necessary tasks associated with investment in the selected projects, monitors the portfolio firms, and assists them with managerial expertise and guidance.[8] The GP uses a variety of methods to reduce agency costs

[6]For example, Cumming and Walz (2010) find that reported expected returns of ongoing investments are higher than the actual realized returns after the exit.

[7]We rely on Sahlman (1990), Gompers and Lerner (1996), (1999), Kaplan and Stromberg (2003), (2004), Hsu and Kenney (2005), Phalippou (2007), and Litvak (2004), as well as various industry sources.

[8]The GP's actions are restricted by the original partnership agreement that can specify the area of investments, the degree of leverage (usually none in VC funds), the maximum percentage invested in a single company, etc.

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

and improve the quality of information about the project: Stage financing is one example. These methods are extensively studied in the literature.

Hsu and Kenney (2005) argue that a limited partnership has a number of beneficial features: One of the most important is that the pass-through profits are taxed only at the investor level. It also provides the GP with the freedom to operate independently, without the interference of the LPs, over a relatively long horizon. Hsu and Kenney also indicate that limited partnership aligns the GP's incentives with those of the LPs via 2 mechanisms: The GP gets a significant portion of the profits, and the limited life of the partnership forces the GP to raise new funds, making a performance-based reputation crucial. Gompers and Lerner (1996) argue that limiting the extent of potential conflicts between the LPs and the GP is critical, since "a single partnership agreement governs the relationship between the Limited and General partners over the fund's life of a decade or more .... [T]hese contracts are rarely renegotiated." Litvak (2004) provides additional details on the contractual provisions between LPs and GPs, in particular focusing on the effects of various profit distribution mechanisms.

VC funds attempt to find good companies and invest intensively in the early stages of the fund, monitor and support portfolio firms in the mid-stage, and accelerate the exit in the last stages. Analysis of 3-stage VC strategies is found in Malherbe (2004). In the process, the GP acquires new information on the project and its estimated value, and the time to exit. The GP also takes into account the opportunity costs of alternative investments in order to maximize the payoff of the entire portfolio. A common practice is a syndicated investment in projects by several funds, which generates additional opinions about the project's quality, as argued by Casamatta and Haritchabalet (2003).

The distribution of payoffs from the fund's investments is in general as follows: The GP receives an annual management fee, usually 1.5%–2.5% of the total fund size committed by the LPs. In addition, the GP receives about 20%—usually called "carried interest" (or "carry")—of the capital gains, which are the total proceeds received during the fund's life less the amounts of the LPs' investment. Only after the LPs are paid in full does the GP start sharing the profits.[9] It is important to mention that deviations from 20% of carried interest are fairly infrequent and small. Gompers and Lerner (1996) argue that these deviations are likely to attract widespread attention, while other covenant items represent a less visible way of making price adjustments. Gompers and Lerner (1999) show that 81% of the 419 funds in their sample have either 20% or 21% carry; older and larger venture groups command a 1% higher carry on average. Litvak (2004) uses a more elaborate methodology, taking into account the timing and risk adjustment associated with the various distribution methods and reports somewhat larger variations in the "real carry" values.[10] To the best of our knowledge, carry remains constant

[9]Litvak (2004) argues that the method of profit distribution is an often overlooked form of control of GPs' compensation.

[10]Metrick and Yasuda (2010) also show that 92% of the 209 recent partnerships (mostly buyouts, which are similarly structured) have a 20% carry, which suggests that these contracts are stable, as Gompers and Lerner (1996) indicate.

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

for all portfolio projects of the same fund, regardless of the nature of the project, and is not contingent on the portfolio company performance.

Limited Life Span

The principal-agent relationship between the LPs and the GP has received relatively little attention.[11] The main mechanisms that LPs use to control the GP are i) the limited life span of the fund, ii) covenants in partnership agreements, and, in extreme cases, iii) an early fund liquidation by a supermajority of LPs when the GP severely underperforms.

Most VC funds (as well as private equity funds) have a 10-year life span, which can be extended by 2–3 years if the LPs agree (see Gompers and Lerner (1999), Phalippou and Gottschalg (2009), and Phalippou (2007)). Usually such extensions are granted. Holdings in projects that did not reach exit by the time of the fund's liquidation are sold to outside investors. Protective covenants often prohibit or severely restrict the sale of these shares to follow-on funds of the same GP (see Gompers and Lerner (1996)).[12] The immediate question arises: Why is the life span so uniform across the spectrum of funds that invest in drastically different fields? Though this question is beyond the scope of this paper—we take the limited life as given—we would still like to outline certain insights that help to put the subsequent model in the right perspective. It is worth noting that LPs (mostly institutions) are usually well-diversified investors with a long investment horizon: The limited life span of the VC fund is not a necessity for them, but rather a reasonable incentive mechanism. In contrast, corporate VCs, have alternative incentive mechanisms and do not limit their VC funds' life spans.

While the finite life span of limited partnerships is mandated by law in the U.S., there seems to be no consensus in the literature on the optimality of the standard life span of VC funds: 10–13 years (see Phalippou (2007)). Sahlman (1990) argues that limiting the fund's life span allows LPs to limit the risk and to discourage the GP from retaining the profits within the fund by infinitely hiding the project's maturity. Gompers and Lerner (2001) note that limited life span is a common feature in other fields where limited partnerships are used, such as oil exploration and real estate development. Phalippou (2007) suggests that the limited life span allows one to calculate the performance fee (internal rate of return (IRR) or profit multiples), which would be hard to compare across varying life spans. He also argues that the uniform 10-year life span may be due to inertia, which few firms are willing to break, so as not to start the negotiations anew. This argument is frequently mentioned by practitioners. We subscribe to all these arguments and add some more structure to this issue.

Modifying definitions from Malherbe (2004), we can broadly partition the life of the fund into a "search stage" and an "implementation stage." During the

[11] Notable exceptions are Sahlman (1990), Gompers and Lerner (1996), (1999), Lerner and Schoar (2004), Litvak (2004), and Phalippou (2007).

[12] In this paper we abstract from the GP's desire to establish follow-up funds and the incentives associated with it. We refer to Hochberg et al. (2008) for a model that specifically addresses the relationship between the LPs and GPs across different funds of the same GP.

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

search stage, GPs are looking for good projects, which takes time. Once projects are identified and GPs invest and commit to future investments (stage financing), they become monitors of the portfolio companies and their advisors. In the implementation stage, GPs are expected to maximize the company's value and bring it to the best possible exit. The limited life span puts the upper bound on the total time taken to find the projects and bring them to fruition. We argue later that the main benefit of the limited life span is in the provision of incentives to the GP in the search phase, while its main cost is in the implementation stage, which is the main emphasis of this paper.

It is worth noting that in the past, the partition to these stages was rather informal. However, recently many funds have begun to contractually restrict the search stage to 5–6 years, after which the GP can no longer make new investments. We consider this to be additional evidence of the severity of the potential agency problem in the search stage, which is consistent with our conjecture.

We identify 2 scenarios in the search stage affecting the choice of the fund's life span:

Scenario 1. The LPs gradually learn about the GP's ability to find good projects, which stays constant over time. This scenario is consistent with the basic intuition of Hochberg et al. (2008), who assume that the main source of uncertainty is the ability of the manager, which the LPs learn about over time.

Scenario 2. There is no information asymmetry about the GP's ability to find good projects, but the ability itself may dramatically decline at some point in time (the decline is observable). This scenario is consistent with the model of Glode and Green (2008), who assume that the main uncertainty and learning pertain to profitability associated with a sector or a trading strategy, rather than ability specific to the fund manager.

LPs are prevented from intervening in the choice of the project and its management. The GP can always invest in bad projects, which are readily available, yet the LPs cannot distinguish them for sure from the good projects ex ante.

The first scenario introduces learning from past performance, where the limited life sets an upper bound on the experimentation time the LPs are willing to tolerate before they choose another GP. This creates incentives for the GP to build its reputation, which allows the GP to raise the next fund. Gompers and Lerner (1999) found that compensation is indeed somewhat higher for older and larger VC funds, while "reputational concerns lead young venture capitalists with little incentive compensation to work hard and perform well." This scenario is consistent with the slightly higher carry charged by more established and successful GPs, as they are perceived to be of higher quality (see Hochberg et al. (2008)). Litvak (2004) reaches the same conclusion using a different proxy for fund quality. But if learning is the main determinant of the life span, then subsequent funds raised by a successful GP should have a much longer life span, which is generally not the case (see Phalippou and Gottschalg (2009)). Of course, the inertia argument offsets the latter prediction, as the GPs may prefer to keep the existing life span rather than engage in lengthy negotiations.

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

It is very reasonable that GPs who were very successful in the past may experience a drastic drop in their ability to find good projects; for example, when the market in which they are experts suddenly becomes much less attractive (e.g., Internet applications after 2000). Under the second scenario the GP has little chance to raise subsequent funds and therefore has an incentive to at least extract all the surplus from the current fund. Setting the upper limit on the GP's ability to draw the management fee and forcing the GP to give up control of the portfolio firms reduces the potential LPs' losses associated with this contingency.

One may ask why the limited life is imposed on the sum of the search and implementation stages if it is only supposed to control the adverse behavior in the search stage. An alternative is to limit the search stage to 5 years and then let the implementation stage last as long as required for successful completion of the project. This is especially relevant given the high cost imposed by the limited life at the implementation stage, as we show later. However, this alternative is potentially very costly, since it gives rise to 2 types of adverse actions: First, the GP who is close to the end of the search period is likely to take a bad project rather than return the money to LPs; and second, the GP can artificially delay the exit to collect additional management fees. Some VC funds have recently started adopting the solution of paying the management fee only during the predefined search stage (typically the first 5 years), which reduces this problem. In what follows, we maintain the limited-life assumption and propose alternatives that do not induce this suboptimal behavior.

Given the limited life span of a fund, the different investment horizons of the GP and the LPs have the potential to create a conflict of interests at the implementation stage and distort their valuation of the same projects: For the GP, the value of projects that are not expected to reach the exit during the fund's life is significantly lower than for the LPs, because it does not carry the full value of its residual claim.[13] Identifying and analyzing these conflicts is the main goal of the paper. We also identify remedies that reduce the inefficiencies at the implementation stage without hurting the incentives at the search stage.

One may question why we focus on the VC industry when the limited liability partnership is widely used in other fields: oil exploration, real estate, private equity, etc. As we show later, 2 components are required to generate the problems we discuss. First, there must be significant uncertainty about the value of the project and a significant degree of information asymmetry between the GP and the market about this value in all stages of the project. Second, significant uncertainty must exist about the time to the fruition of a project, and information asymmetry must exist between the GP and the market. VC funds invest in projects that satisfy both conditions, while others do not.

III. Model

In this section we analyze the GP's decisions to continue/terminate projects at the intermediate stage. In real life, new investment opportunities emerge during

[13]Litvak (2004) provides a model for the time effect estimation on the real values of the carry and management fee received by the GP during the fund life.

the fund's entire life. However, the problem of an inefficient continuation/termination decision becomes more acute closer to the fund's maturity because of the increased probability of ending up with an unfinished project. Therefore, for the sake of simplicity, we consider a 2-period model, in which the fund starts and long-term investment opportunities arise at the same time, $t = 0$ (which summarizes the search and the project selection stage).

Our analysis is conducted at the individual project level. We ignore interactions between different projects in the fund's portfolio and questions of the optimal portfolio size.[14]

A. Investors

As mentioned previously, we assume that a VC fund exists for 2 periods: It is created at $t = 0$ and must be dissolved at $t = 2$. The fund has 2 types of partners: the GP, who manages the fund, and LPs, who are "passive" investors with cash claims on the fund's profits. At $t = 0$, LPs commit to provide the entire capital for investment at the GP's calling but cannot make any project-related decisions.

We make the following assumption:

Assumption 1. The GP's compensation is linear in the fund's profit.

As described in Section II, the GP normally receives his compensation in 2 forms: as a preagreed management fee, which is in general a percentage (1.5%–2.5%) of the fund's size, and the "carried interest," c, usually 20% of the fund's capital gains. Since in our model the LPs do not learn the quality of the project at $t = 1$, we assume that they always provide the capital "on call" and set the fund management fee to 0 without loss of generality. At this stage we treat c as exogenous, but later we endogenize it.

Risk aversion unnecessarily complicates the exposition; thus it is assumed away.

B. Projects

The GP can invest in 2 types of projects.

Long-term projects require unverifiable monitoring for 2 periods; m is its cost per period. Monitoring is any unobservable effort the GP must put into the project, such as advising and motivating the managers, negotiating with partners, providing professional services, etc. Without monitoring, the payoff to investors is assumed to be 0.[15] If monitoring takes place in both periods, the payoff is random; it is equal to V with probability p, and 0 with probability $(1 - p)$. Monitoring is not observable by the outside parties, including the LPs.

The novel assumption is that the timing of the payoff is random as well. Long-term projects can take either 2 or 3 periods to finish.[16] The prior probability

[14] Optimal portfolio size is studied in Kanniainen and Keuschnigg (2003). For effects of interaction between portfolio projects, see, for example, Leshchinskii (2010).

[15] "Zero payoff" is largely accepted in the literature (see, e.g., Gompers (1995)).

[16] For simplicity we assume that no monitoring is required in the 3rd period. Clearly, in reality some monitoring may be required, but we assume that the company is sold to an outsider that

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

that a project ends on time varies across projects. Proportion γ of all projects has a high probability of ending after 2 periods, q_H, while the rest have a low probability, q_L. In the beginning nobody knows the true project type; thus the prior probability that the project ends on time is

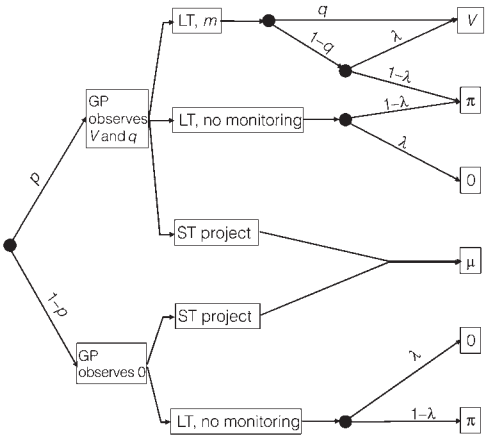
$$q_0 \equiv \gamma q_H + (1-\gamma) q_L.$$

If the project ends on time, that is, the GP brings the project to an exit through an initial public offering (IPO), merger and acquisition (M&A), or write-off, the project's payoff becomes public knowledge. The GP can also hide information about the project's progress, claiming that the project has not ended yet and keeping the payoff unknown. However, we assume that at $t=2$ the market may learn the true value of the project with probability λ, which may vary across VC fields.[17] The payoff structure of long-term projects is depicted in Figure 2. We postulate that the risky long-term projects are the main reason for the existence of the VC industry.

FIGURE 2

Long-Term Project's Payoff to the VC Fund

Figure 2 shows a long-term (LT) project's payoff to the VC fund. One period before the fund's maturity the GP observes the project's quality (the payoff to the fund is V for a good project and 0 for a bad project) and the probability q of its ending by the fund's maturity. The GP must decide whether to continue the project (with or without monitoring m) or whether to replace it by a short-term (ST) project with payoff to the fund μ. π is the expected value of the project of unknown quality, given that its value is unknown or undisclosed.



Short-term projects yield a payoff μ after 1 period. We assume that these projects require much less monitoring (normalized to 0). These projects can be

is not subject to the limited life span, who will certainly invest in monitoring. We have solved the model by assuming that the value of the unfinished good project is $V - m$, instead of V, which further reduces the incentives to monitor delay-prone projects, and thus strengthens our results.

[17]How well the GP can hide the project's progress depends on the nature of the project itself. We can imagine that some outcomes are easier to hide than others. Clearly, one cannot hide an exit or a write-off, but one can postpone them, claiming that the project is not finished yet. We assume that for early-stage projects the GP can conceal their progress more easily.

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

interpreted as either the return of the money to LPs (in which case μ is equal to the investment) or as "safe" investments in existing long-term projects with a small positive return. In any case, such investments could not be too profitable or the GP would have targeted them from the beginning.

We use the following simplifying assumptions, and all results still hold without them. Assumption 3 is a common practice of many VC funds. It means that at $t = 1$ the GP cannot reinvest proceeds from a finished short-term project into a new short-term project.

Assumption 2. All projects need the same per-period investment, normalized to 0.

Assumption 3. Proceeds from projects cannot be reinvested in new portfolio projects.

Assumption 4. The interest rate is 0.

At $t = 1$ the GP learns *for sure* the long-term project's potential payoff: V for good projects and 0 for bad. He also learns the true probability that the project will end at $t = 2$: $q \in \{q_L, q_H\}$. The LPs still only know the prior distribution of the project's quality, Prob(Good) $= p$, as well as of the project's probability of being delayed, q_0. Thus, there is a double information asymmetry between the GP and the LPs at $t = 1$, when the GP decides whether to continue the project, with or without monitoring, or to abandon it and start a short-term project.

At $t = 2$ the VC fund is dissolved, and its proceeds are distributed between the GP and the LPs. If the project has ended by $t = 2$ and the GP has revealed this information or the market has learned it independently, the VC fund receives the value of the project. If the project remains unfinished and the market does not learn its quality, then it is sold to outside investors at the market (uninformed) price, which we refer to as the "fair price."

C. The First-Best Outcome

We derive the overall first-best outcome as a benchmark for our results. Once the project's quality becomes known to the GP, only good projects should continue, while bad projects should be replaced by short-term projects. Thus, at $t = 0$, the expected payoff of a long-term project must exceed that of investing in 2 consecutive short-term projects:

$$p(V - m) + (1 - p)\mu - m \quad > \quad 2\mu. \tag{1}$$

This implies that the VC fund should invest in risky long-term projects at $t = 0$ if and only if (iff):

$$V \quad \geq \quad (m + \mu)\frac{1 + p}{p}. \tag{2}$$

We assume that inequality (2) holds, which ensures that only economically viable long-term projects receive VC funding at $t = 0$.

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

D. Results

The main player in this game is the GP, who at $t = 1$ holds a double informational advantage. If at $t = 1$ the GP continues a good project and monitors, then with probability q the project ends at $t = 2$ and its true value is revealed and distributed. With probability $(1 - q)$ the project remains unfinished, and the GP is obliged to sell his stake. With probability λ the market learns the true value of the project, otherwise the fund gets its "fair value," which we denote by π. In a competitive market, where all participants are risk-neutral, π is the expected value of the project, conditional on the market remaining uninformed. By the time the GP receives the information about the project at $t = 1$ and has to decide on continuation, the 1st-period monitoring is a sunk cost. The expected profit for the GP depends on the quality of the project, its expected time to fruition, and whether the GP monitors it. The payoffs are as follows:

(3)

q	Project Type	Monitoring	Project Value	GP's Expected Payoff
	abandon LT/ switch to ST	No	μ	$c\mu$
q_H	LT	No	0	$c\pi(1-\lambda)$
q_L	LT	No	0	$c\pi(1-\lambda)$
q_H	LT	Yes	V	$c\left[(q_H + \lambda(1-q_H))V + (1-q_H)(1-\lambda)\pi\right] - m$
q_L	LT	Yes	V	$c\left[(q_L + \lambda(1-q_L))V + (1-q_L)(1-\lambda)\pi\right] - m$

The fair value, π, depends on the equilibrium strategies of the GP.[18] Formally,

$$(4)\quad \pi = \mathrm{E}\{\text{value}|\text{unfinished project}\} = V \cdot \Pr\{V|\text{ unfinished project}\} = V \cdot \frac{\Pr\{\text{unfinished project}|V\}\Pr\{V\}}{\Pr\{\text{unfinished project}|V\}\Pr\{V\} + \Pr\{\text{unfinished project}|0\}\Pr\{0\}}.$$

Notice that if all the unfinished projects are good, then $\Pr\{0\} = 0$ and $\pi = V$.

The first result of the paper shows that the first-best cannot be attained. Formally, we have:

Proposition 1. If the unfinished projects are fairly priced, that is, $\pi = \mathrm{E}\{\text{value}|\text{unfinished}\}$, and $\lambda < 1 - ((\mu p)/((m+\mu)(1+p)))$, then no equilibrium exists in which bad projects are terminated at $t = 1$ for sure.

Proof. Suppose that such an equilibrium exists. Since all bad projects are terminated, then $\Pr\{0\} = 0$, and by equation (4) we should have $\pi = V$. To induce termination of bad projects, the GP's payoff from their continuation should

[18] It is possible to imagine a situation in which $\pi \neq \mathrm{E}\{\text{value}|\text{unfinished}\}$. For example, at $t = 0$ the GP can sell the LPs a forward contract with a predetermined price π on all projects unfinished at $t = 2$. This pricing can possibly improve the efficiency of the GP's decision concerning the project's termination/continuation by creating a commitment mechanism to terminate bad projects. We will show the rationale for that in the next section.

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

be less than his payoff from starting a safe project, that is, $(1-\lambda)\pi \leq \mu$, which implies that $(1-\lambda)V \leq \mu$. This inequality contradicts inequality (2) for $\lambda < 1 - ((mp)/((m+\mu)(1+p)))$. □

The intuition behind this result is easy to see when $\lambda = 0$; that is, the market never learns the quality of allegedly unfinished projects. The short-term projects must be significantly less profitable than the long-term project, $\mu \ll V$, to justify the existence of the VC fund. The price of an unfinished project is a weighted average between V and 0, since some of the unfinished projects are necessarily good. The combination of the two is such that the GP prefers to continue a bad project and sell it as unfinished, rather than abort it in favor of a short-term project. The result holds as long as the market cannot learn the quality of the project with high precision (i.e., λ is relatively low).[19]

Proposition 1 implies that the unfinished project's expected value π exceeds the safe project's payoff, μ divided by the probability that the market remains uninformed.

If no good projects are ever chosen to be continued at $t = 1$, then any unfinished project is worthless, that is, $\pi = 0$, which creates a contradiction. This means that at least when $q = q_H$, the GP must continue monitoring good projects. However, the following proposition shows that under some conditions the GP may stop monitoring delay-prone projects and sell them as unfinished:

Proposition 2. Let us denote $M \equiv m/c$. If $\lambda < 1 - ((\mu p)/((m+\mu)(1+p)))$ in the game described previously, then there exist 2 types of equilibria in pure strategies:

1. For M satisfying

$$M \leq V\left[\lambda + \frac{q_L(1-\lambda)(1-p)}{1-pq_0}\right], \tag{5}$$

there exists an equilibrium in which all projects are continued, and all good projects are monitored.

2. For

$$\lambda V + q_H(1-\lambda)V\left(\frac{1-p\gamma}{1-p\gamma q_H}\right) \geq M > \lambda V + q_L(1-\lambda)V\left(\frac{1-p\gamma}{1-p\gamma q_H}\right), \tag{6}$$

there exists an equilibrium in which all projects are continued. Good projects that are delay-prone are not monitored.

Proof. See the Appendix.

[19] Assuming a 5% success rate and a monitoring cost on the order of magnitude of 10% of the payoff of the safe project, $m = 0.1\mu$, the value of λ must exceed 0.95 to violate the inequality. In most high-tech fields it does not seem reasonable that the market can learn the quality of the project at such a high level of precision.

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

Comparing the previous conditions, we conclude that no M can satisfy expressions (5) and (6) at the same time. Some M, however, satisfy neither, suggesting mixed strategy equilibria, the derivation of which is available from the authors.

Notice that an increase in μ and p, and a decline in λ, q_L, c, and V, reduce the region in which all good projects are monitored. The crash of NASDAQ in 2000 significantly reduced the valuations, V, and arguably increased the expected time to exit (i.e., reduced q_L, q_H, and γ). It is likely that it also increased the uncertainty in the unfinished project valuation, reducing λ. All of these suggest an increase in the likelihood of the inefficient equilibrium. We plan to use this event to present some supporting evidence later in the paper.

Finally, the cross-sectional variation in λ across industries allows us to make predictions regarding different types of VC fund projects. Industries with easy detection of bad projects should suffer less from the GP's myopia than industries in which such detection is difficult.

IV. Extensions

In this section we explore various extensions of the basic model as well as modifications of the contract that could potentially alleviate the inefficiencies to some extent.

A. Model Modifications

1. All Projects Are Good, but Unobservable

Suppose that all the projects are good, but their outcome is unobservable to the market, and this fact is common knowledge, which is tantamount to $p = 1$ and $\lambda=0$. This rules out the inefficient continuation of a priori bad projects, since there are none. The question is whether some good projects stop being monitored. Modifying Proposition 2, we immediately conclude that the equilibrium in which all the good projects are continued is no longer viable; thus any pure strategy equilibrium involves inefficient termination of monitoring of delay-prone projects. The intuition is straightforward: If all good projects are continued, the GP gets the same payoff for unfinished projects whether he monitors or not, which causes him not to monitor them. A pure strategy equilibrium with partial monitoring exists iff

$$\lambda V + q_H(1-\lambda)V\left(\frac{1-\gamma}{1-\gamma q_H}\right) \quad \geq \quad M \quad > \quad \lambda V + q_L(1-\lambda)V\left(\frac{1-\gamma}{1-\gamma q_H}\right).$$

For values of M greater than the left-hand side of the previous inequality, no VC funds ever exist, while for values of M less than the right-hand side, we obtain a mixed strategy equilibrium. This result suggests that the possibility of the inefficient abandonment of the delay-prone projects does not depend on the continuation of bad projects. The intuition is similar to that of Aghion et al. (2004) and Faure-Grimaud and Gromb (2004), who investigate the strategic sale of projects prior to completion, which allows their managers to save on monitoring costs.

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

2. Endogenous Carry Rate

In previous sections we treated the carry, c, as exogenous,[20] while focusing on the GP's strategy in continuing or terminating projects at $t = 1$. One could enrich the analysis by incorporating the choice of c into the model. This requires additional assumptions and is beyond the scope of this paper; thus we only briefly discuss the intuition. If the bargaining power is in the hands of the LPs, they will choose the minimal c in each equilibrium and then compare across the equilibria. If GPs hold the bargaining power, they will do the same but will choose the maximal c. In any case the choice in both cases depends on all the parameters, and according to our simulations (available from the authors) the choice is especially sensitive to the value of q_L, as q_L is the most important parameter for the equilibrium selection. In fact, our simulations indicate that the optimal carry rate is not monotonic in q_L and can vary dramatically.

As stated previously, many LP-GP contracts have c set to 20%, and deviations are not large (see Gompers and Lerner (1996), but also Litvak (2004)). Also, the norm in the industry is that the GP's share always remains constant for all portfolio projects of the same fund. The intuition of our model clearly suggests that using the same carried interest for all types of projects is suboptimal: Biotechnology projects should be financed under different contracts than Internet start-ups or projects from the medical equipment field. By the same token, the carried interest should have changed after the NASDAQ crash in 2000, because a significant increase in the expected time to exit warrants it. It is puzzling, therefore, to observe such low variation in c across fields, across projects, and over time. One possible explanation is that this issue has started worrying the practitioners only recently, and the process of change may be under way. Another factor, which is frequently raised by GPs, is their hesitation to open negotiations with the LPs, as these may include items that GPs would rather not touch.

B. Contract Modifications

Limited life span serves a useful purpose; thus it is unlikely to disappear. Can LPs change the contracts to reduce the costs associated with the 2 inefficiencies identified previously? Several possible courses of action immediately come to mind. First, one can reduce the GP's incentives to disguise bad projects as unfinished. Second, one may increase the GP's horizon and remove the very fact of sale of unfinished projects. Finally, one may try to reduce the information asymmetry between the GP and the outside market. Later we suggest several specific contractual provisions and point out similar provisions already used in the industry. These should be viewed as indicative rather than prescriptive. Litvak (2004) describes various additional contractual provisions, which may alleviate the problem to some extent as well.

[20] Interestingly, in almost all LP-GP contracts, c is set close to 20% (Sahlman (1990), Gompers and Lerner (1999)). While Gompers and Lerner (1999) document about a 1% greater share commanded by the oldest and largest venture groups, the GP's share remains constant for all portfolio projects of the same fund. However, our model suggests that a rational LP should choose c to minimize the inefficiency zone, thereby varying it across types of projects.

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

1. Giving the GP a Lower Stake in the Unfinished Projects

One may make the compensation of the GP contingent on the status of the project, not unlike debt contracts that are contingent on the state of nature. Suppose that the GP gets a kc stake in the proceeds from the unfinished projects, where $k < 1$. It can be easily shown that if k is low enough, then the GP does not have an incentive to hide bad projects as unfinished ones. This direction may seem somewhat puzzling, since it further increases the gap between the incentives of the LPs and the GP by reducing the attractiveness of the delay-prone projects to the latter. However, it also reduces the attractiveness of keeping the bad projects, and the overall effect is positive. Consistent with this course of action, some funds allegedly allow 0 carry on unfinished projects.

2. GP Keeps Cash Flow Claims in Unfinished Projects

Another way of alleviating the problem is to reduce the very need of the GP to sell the project when the fund is dissolved. One way to accomplish this is to award the GP cash flow rights, but grant him no control over the decisions in the unfinished projects beyond the end of the VC fund's life.[21] As pointed out previously, the LPs limit the lifetime of the fund to restrict the opportunistic behavior of GPs, but LPs should not be averse to extending the cash flow rights of GPs in unfinished projects. Suppose that these cash flow rights allow the GP to get share c of the project when it comes to fruition, and these rights are not vested before that, so that the VC fund cannot sell them prior to the "exit" of the LPs.

Since the sale of the project is no longer mandatory, a standard "lemons" argument would imply that the GP would not be able to sell his stake in unfinished projects. The GP has an incentive to keeps the good and terminate the bad projects, which implies that all unfinished projects must be good (i.e., $\pi = V$).

This provision also eliminates the GP's myopia with respect to the delay-prone projects, since his incentives are the same as with the non-delay-prone projects. Consequently, this seemingly allows for a first-best solution; however, it does not take into account the cost imposed on the GP by this arrangement. If the GP owns major stakes in several companies that are still not ready for exit, it may affect the new funds that the same GP manages. Nevertheless, this provision may limit the inefficient behavior of the GP.

Notice that the 2 previous provisions impose opposing restrictions on the GP's rights to the unfinished projects. While giving the GP a lower stake in unfinished projects ($k < 1$) acts as a punishment, adding extra compensation for unfinished projects is more like a reward compared to the base case where the unfinished projects must be sold. The LPs can use these 2 mechanisms to fine-tune the GP's incentives based on the characteristics of the project.

[21] Without the separation of control and cash flow rights, keeping the stake in the project induces a certain cost on the GP (liabilities, reputation, signaling, etc.), which is not covered by management fees after the fund's end. Consequently, it is optimal for the GP to keep such stakes only in high-value projects with a low probability of delay, and this seems to happen in reality. However, if only the cash claims are preserved after the fund's end, the GP becomes a passive investor similar to the LPs, and the conflict of interests disappears.

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

3. VC Fund Syndication

Notice that the basic problem is a combination of limited life span and information asymmetry. The contract provisions outlined previously focused on dealing with limited life span. An alternative is to reduce information asymmetry. A VC fund with a short time horizon may invest in syndication with a younger VC fund, which is not subject to the same binding time constraint. During their joint monitoring of the company, the GP of the younger VC fund is exposed to private information about the project. Consequently, if the project is delayed, then the older VC fund can sell the unfinished good project to the younger fund, significantly reducing the adverse selection discount. On the other hand, it will not be able to sell bad projects; thus it would not want to continue them. Similar arrangements can be made with corporate VC funds, which are not subject to the limited life constraint.

Notice that the proposed contractual provisions may significantly reduce the efficiency loss associated with the limited life span during the implementation stage. At the same time, these provisions do not directly affect the incentives during the search stage of the fund. In fact, since the values of the implemented projects are likely to increase after the implementation of these provisions, they should improve the search-stage incentives as well, ceteris paribus.

V. Empirical Implications and Some Evidence

The discussed model yields several empirical predictions, which are potentially testable. We outline these predictions later and present some evidence.

A. Empirical Implications

The main prediction is that the fund's remaining horizon should have a profound effect on the financing decisions of the GP. Continuation decisions made when the fund is young are likely to differ from the decisions later in the fund's life. If we were to observe the quality of the project and the actual investment of the GP in monitoring the project, then we could test whether older funds indeed stop monitoring good but delay-prone projects, which they can later camouflage as unfinished ones. While we may be able to observe proxies for the quality of the project ex post, we cannot observe the GP's effort; thus we cannot test this prediction.

The second set of predictions has to do with the exogenous parameter changes and their effects on the behavior of the GP and the resulting changes in the efficiency of VC funds. We conjecture that a structural change took place in this industry following the sharp decline in the NASDAQ valuations in 2000. It is widely accepted that this event resulted in the decline of the exit valuations, V, and in the lower proportion of good projects, p. The effect of these changes on the decisions of all the VC funds should not be correlated with their age. At the same time there was an increase in the average time to exit, which in our model would imply that both q_L and q_H (and perhaps γ) declined. In addition, it seems that the range, $(q_H - q_L)$, increased as well. All these data suggest that for the funds that are closer to their termination date, the misalignment of the GP's and the LPs'

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

incentives increased after 2000, which would imply an increase in the associated inefficiency. Later we use this exogenous event to illustrate the effect of the age of the fund on its decision making.

Another way to explore the effect of parameters is to focus on segments of the industry. If one is able to establish a connection between the technology type and some of the parameter values, it may be possible to test the predictions of the model with respect to its parameters. For example, the specific technology development cycle (proxied by q_0) is much longer for biotechnology and medical equipment than for software and communications. Moreover, valuation and its uncertainty (V and p) are different for consumption goods than for the Internet technologies. Other parameters may predictably vary across industries as well.

We have shown that various contractual provisions may alleviate the problem: adjusting the carried interest, c, to the specific environment of the VC funds; reducing (or eliminating) the GP's stake in the unfinished projects; letting the GP keep cash rights in the unfinished projects; or establishing syndicates between VC funds of varying age—all these provisions should reduce the degree of inefficiency.[22] Given data on contractual provisions for a sample of VC funds, one can relate them to the proportion of their good projects that are abandoned or left unfinished.

B. Some Evidence

It is well established that VC-financed firms are overall less likely to fail than the non-VC-financed firms. Puri and Zarutskie (2008) show this result as well, but they go further by showing that this difference is strong in the first 5 years of the VC fund. In later years the sign changes: VC-financed firms become more likely to be shut down given similar measures of success. These results are consistent with the predictions of the model that GPs shut down delay-prone firms toward the end of the fund's life, whereas non-VC firms suffer no such bias.[23]

Yuklea (2007) provides experimental evidence that is consistent with the predictions of the model. He administered a Web-based survey that presented subjects with scenarios involving continuation/abandonment decisions on a synthetic portfolio of companies matching the dimensions used in this paper (good/bad, on-time/delay-prone, safe/risky). The experiment is based on responses of 108 VC-related professionals, each making 5 separate abandonment/retention decisions. GPs chose to continue over 40% of the bad projects and to discontinue 26% of the good but delay-prone projects. Of the non-GP participants (LPs, corporate VC managers), who are not supposed to be subject to this myopia, only 31% chose bad project continuation and only 13% discontinued good but delay-prone projects. Both suboptimal decisions are positively and statistically significantly correlated with the predicted myopia of the practitioner.

[22]Cumming and Walz (2010) report that syndicated investment seems to add value to portfolio companies.

[23]This is not a unique interpretation of these findings. It is possible that in the first 5 years, non-VC firms suffer from a shortage of capital; thus VC firms are less likely to fail. At the same time, it could be that VC firms are in general quicker to write off a nonperforming firm than managers/owners of a non-VC firm. We thank the referee for pointing this out to us.

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

We can neither observe the quality of the project ex ante, nor when a GP stops monitoring a delay-prone project. In the model we assume that the sale of unfinished projects takes place only at the end of the life of the VC fund, that the VC fund does not have investment constraints, and that the GP can always disguise a nonmonitored project as a good unfinished one. In reality, the GP may have the option to invest in other projects in order to bring them to the market faster. Thus, instead of investing in delay-prone projects without any intention of bringing them to fruition (as in the model), the GP may stop the investment by not participating in future investment rounds. In these cases, the abandonment of the project by the VC fund is observable. According to our predictions, VC funds with shorter horizons are more likely to abandon, which is what we attempt to show. This exercise is mostly for illustration purposes, and more detailed data are required to test these hypotheses formally.

We use the exogenous crash of the technology stocks in 2000 to identify the magnitude of this effect. We have argued that the post-2000 market is characterized by lower valuations, as well as a longer and much more variable time to exit. The latter amplifies the conflict between the GP and the LPs stemming from the limited time horizon-induced myopia. We expect this feature to be the most pronounced in the projects that started and were financed by the VC funds before the 2000 crash, and then suffered an exogenous shock. As we do not observe the quality of the project at the time of the investment, we restrict our attention to firms of a sufficiently high quality, which we proxy by the fact that they got an exit by 2005. We focus only on these projects in our empirical illustration.

We extract 2 samples from Thomson Financial's VentureXpert database. We first create the "companies" sample, which contains information on the portfolio companies and their investment rounds, including investors' identities and the date of the round starting in 1993. We also obtain information about the status of the company in 2005 and determine whether it had made an exit by that time (IPO or acquisition) or not. We classify the companies that had made an exit by 2005 as "good" projects. This approach does not require valuation of the company as long as we know that somebody was interested enough to buy it after a while. Then we create the "funds" sample, which contains information on the investment funds (not only VC funds) that appear in VentureXpert and their portfolio companies.

We then restrict our sample to only the "good" projects that satisfy the following additional criteria:

- The company was established after 1993 and had its first investment round before 2000.
- The company received at least 1 follow-up investment round after the year 2000, so we have an observation on a decision to invest.
- At least the first 2 investment rounds were syndicated (more than 1 investor). Single-investor companies may operate under a fundamentally different set of constraints; thus we do not mix them with the rest of the sample.
- The observation is a fund's participation or nonparticipation in a post-2000 financing round.

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

These additional restrictions yield a post-2000 sample containing 1,858 decisions to abandon and 894 decisions to continue in 1,147 investment rounds. For comparison we also look at the rounds prior to the year 2000, even though they cannot be considered as a control sample, since the projects are at different stages of development. There we have 487 abandonments and 332 continuations in 320 rounds of investment. Table 1 presents the sample.

TABLE 1

Annual Distribution of Abandonment and Continuation Decisions

Table 1 presents the annual distribution of abandonment and continuation decisions in the sample of firms that completed an exit by 2005 and had at least 1 round of investment before 2000. The number of investment rounds in each particular year is a benchmark for funding intensity. Pre-2000 data are presented for comparison.

	No. of Observations	No. of Abandonments	No. of Continuations	No. of Rounds
1993	4	2	2	1
1994	10	4	6	4
1995	13	8	5	6
1996	35	23	12	15
1997	54	32	22	22
1998	210	121	89	79
1999	493	297	196	193
1993–1999	**819**	**487**	**332**	**320**
2001	1,034	712	322	426
2002	685	463	222	281
2003	449	294	155	194
2004	357	245	112	194
2005	227	144	83	94
2001–2005	**2,752**	**1,858**	**894**	**1,147**
1993–2005	**3,571**	**2,345**	**1,226**	**1,467**

First, we show that the age of the VC funds has a significant effect on the decision to abandon good projects ("good" is defined by the ex post realization). Figure 3 presents the distribution of the ages of VC funds that continue a project in which they had previously invested, and VC funds that abandon such projects. It is easy to see that the latter first-order stochastically dominates the former. This indicates that there is a clear relation between the VC fund's age and the abandonment decision: Older funds are more likely to abandon good projects. While this is consistent with the predictions of the model, it may also stem from other reasons. Figure 4 presents the same distributions for the non-VC investment funds such as private equity, corporate VC, and others. The main difference between the 2 groups is that the latter has either an unlimited or a very long time horizon; thus the myopia identified in the model does not apply. We expect the age of these funds to play a much smaller role in the abandonment decision, and this is exactly what we observe. The average age of the continuing investors is actually higher than that of the abandoning ones, in stark contrast to the VC funds' age distributions. We attribute these differences to the limited time horizon of the VC fund organized as a limited partnership.

Next we present a parametric test of the effect of the VC fund's age on the abandonment decision. For every observation we define the following variables:

ABANDON—an indicator variable taking the value of 1 if the fund does not invest in the subsequent round of a company, in which it had already invested prior to 2000. This is the decision variable we are trying to explain.

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

FIGURE 3

Distribution of VC Funds' Age at the Time of Abandonment/Continuation Decision in 2001–2005

Figure 3 shows the distribution of VC funds' age at the time of the abandonment/continuation decision in 2001–2005. The line with diamond markers is the histogram of the age of funds at the time when they abandon their investment projects, and the line with square markers is the histogram of the age of funds at the time when they decide to continue investment.

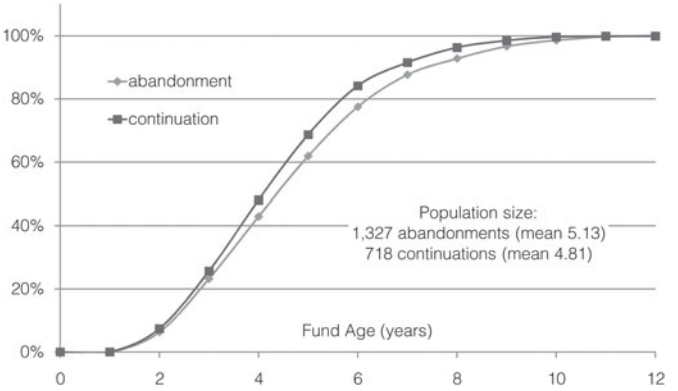
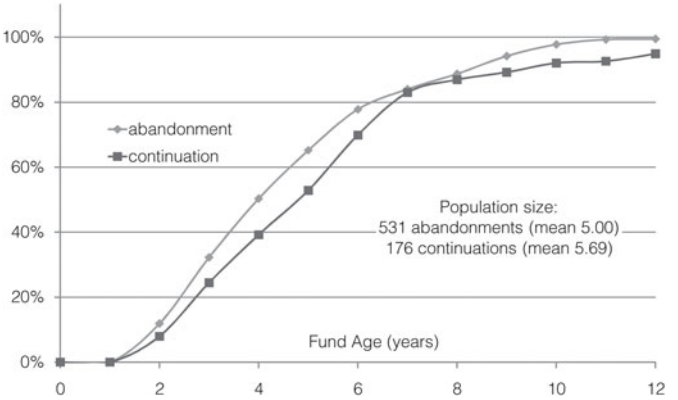


FIGURE 4

Distribution of Non-VC Funds' Age at the Time of Abandonment/Continuation Decision in 2001–2005

Figure 4 shows the distribution of other (non-VC) private equity funds' age at the time of abandonment/continuation decision in 2001–2005. The line with diamond markers is the histogram of the age of funds at the time when they abandon their investment projects, and the line with square markers is the histogram of the age of funds at the time when they decide to continue investment.



AGE—the age of the fund at the time of the decision. This variable should capture the effect of the age on the propensity to abandon projects. We have no prediction on the sign of the coefficient.

VC—an indicator variable taking the value of 1 if the fund is a VC (over 73% of the investors in our sample). It captures the propensity of VC funds to abandon projects midway, relative to other investment funds. We have no prediction on the sign of the coefficient.

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

AGE_VC—a product of the VC and the AGE variables. The first prediction is that the coefficient on this variable should be positive. Older VC funds should be more prone to abandoning good projects than younger funds.

CVC—an indicator variable taking the value of 1 if the fund is a corporate VC (10% of the investors in our sample), which does not have a limited life span. We use this variable to compare the propensity of the CVC to abandon projects relative to other investment funds, including the VC funds. We have no prediction on the sign of the coefficient.

AGE_CVC—a product of the CVC and the AGE variables. If the GP myopia developed with age is caused by the limited life span of VC funds, then the second prediction is that this variable should not have explanatory power, as CVC has no limits on life span.

Table 2 presents the results of probit regressions, which make use of these variables to explain the abandonment decision. The 2001–2005 sample regressions are in the first 2 columns. It is clear that the results are consistent with the predictions of the model: The VC fund's age significantly increases the likelihood of the abandonment decision of a good project, whereas the CVC age has no effect on it. This suggests that this result is driven by the myopia associated with the limited life span. This seems to be a post-2000 phenomenon, as the pre-2000 sample does not show such results.

TABLE 2

The Effect of the VC Fund Age on the Abandonment Decisions

Table 2 provides results of probit regression with decision to abandon being the dependent variable. Standard errors are given in parentheses. * indicates significance at the 5% level.

	2001–2005		1993–1999	
Variable	(1)	(2)	(3)	(4)
AGE	–0.062*	–0.072*	–0.018	–0.019
	(0.02)	(0.024)	(0.055)	(0.061)
VC	–0.887*	–0.891*	–0.455*	–0.393
	(0.142)	(0.125)	(0.221)	(0.241)
AGE_VC	0.115*	0.125*	0.076	0.078
	(0.025)	(0.028)	(0.063)	(0.068)
CVC		–0.133		0.318
		(0.253)		(0.497)
AGE_CVC		0.055		0.040
		(0.046)		(0.148)
N	2,752	2,752	819	819

Perhaps our finding captures a mechanical relationship associated with the age of the portfolio firm, rather than the age of the VC fund. Another possibility is that the previous regression somehow captures the differences between VC funds operating in different fields or between VC and non-VC funds. To test the robustness of our findings, we introduce 2 modifications of the probit regressions for the 2001–2005 period. First, we account explicitly for the age of the portfolio company at the time of the continuation decision, COMP_AGE, as well as for the product of the age of the portfolio company and the VC fund indicator,

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

COMP_AGE_VC. This results in a loss of 129 observations for which VentureXpert does not report the age of the firm. We run this regression for the entire sample as well as by industry of the portfolio companies: information technology (IT), life sciences, and non-high-tech, which are identified in the data.[24]

Table 3 presents the results of probit regressions described previously for the 2001–2005 period. The dependent variable is, as before, the abandonment decision. The age of the company does not seem to drive the abandonment decision, whereas the older VC funds are even more likely to abandon than before. The effect is very similar for IT and life sciences, yet is absent in the non-high-tech firms. While it may be due to other factors, the potential differences in the difficulty of hiding bad projects may account for some of these findings. Another possibility is that non-high-tech companies have a lower degree of uncertainty about the quality of the project and its time to completion, relative to the high-tech firms.

TABLE 3

The Effect of VC Age and Portfolio Firm Age on Abandonment Decisions

Table 3 presents results of probit regression with decision to abandon being the dependent variable. Standard errors are given in parentheses. * indicates significance at the 5% level.

Variable	All	IT	Life Sciences	Non-High-Tech
AGE	–0.108*	–0.096*	–0.119	–0.001
	(0.030)	(0.038)	(0.064)	(0.100)
VC	–1.354*	–1.357*	–1.838*	–1.327*
	(0.214)	(0.266)	(0.558)	(0.617)
AGE_VC	0.180*	0.168*	0.183*	0.117
	(0.037)	(0.046)	(0.083)	(0.118)
COMP_AGE	0.007	–0.021	0.083	0.023
	(0.009)	(0.016)	(0.047)	(0.020)
COMP_AGE_VC	0.005	0.011	0.081	–0.013
	(0.010)	(0.019)	(0.048)	(0.021)
N	2,623	1,827	472	324

Overall, this illustrative example suggests that the myopia associated with the limited life span of the VC funds may have contributed to the decisions of older VC funds to abandon good projects. As we do not find this effect for the corporate VC funds, the difference is likely due to the limited life span of the VC fund. Moreover, the effect is only becoming pronounced in the post-2000 period, suggesting that following the NASDAQ crash this issue became a noticeable concern for the VC funds. It is worth mentioning that this is only one manifestation of the inefficiencies presented in this paper, as we limit ourselves to companies that made an exit ex post. We cannot estimate how many potentially good companies folded because their "myopic" investors abandoned them.

[24]We have also performed the same analysis on a sample containing only VC funds in the 2001–2005 period. The coefficient of the fund age is 0.05, which is almost the same as the sum of the 2 coefficients, AGE and AGE_VC, in Table 2, and highly significant. Thus, even though the types of projects in which different types of funds invest may be different, this does not seem to drive our results. We have also included the company's age and the time since the first investment was made in this company. Neither came close to being significant.

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

VI. Conclusion

The problem we study stems from the GP's myopia induced by the finite life span of the VC fund, and by the GP's information advantage relative to other agents. Our model shows that under the standard VC fund contracts, the first-best outcome is not attainable.

This paper analyzes the negative effects of a limited life span, which is supposed to solve the agency problem between the GP and the LPs. We develop a simple model that reveals the suboptimal nature of continuation/write-off decisions a few years before the fund's maturity. We show that selling unfinished projects at a competitive price or termination of all unfinished projects at the fund's maturity leads to suboptimal decisions during later stages of investment. A VC fund in which the GP sells his stakes at a competitive price tends to continue all poor-quality projects, thus decreasing the overall quality of portfolio projects. A VC fund that terminates all unfinished projects at the end of the fund's life should have a portfolio of much higher quality. This, however, may come at the cost of writing off some good projects.

We propose several possible contractual remedies: lower stakes in the unfinished projects for the GP, retention of cash rights by the GP in the unfinished projects, and costly quality verification, for example, in the form of a simple syndication between the short-horizon fund and a long-horizon one. These provisions increase the efficiency of the operation stage of the VC fund, while not adversely affecting the incentives of the search stage. In other words, they do not seem to worsen the agency problems that the limited life is supposed to alleviate.

The model generates several empirical implications: the misalignment of the GP's and the LPs' incentives (and consequently the loss of efficiency) increased in the "post-bubble" period due to structural changes in exogenous parameters influencing the GP's behavior. Moreover, VC funds that write off all the unfinished projects, or allow the GPs to maintain cash flow rights in unfinished projects, should exhibit a higher average quality of projects and better profitability. Syndicates of VC funds of different ages should have a lower termination rate of good projects than more homogeneous syndicates. However, the proportion of successful exits decreases with the age of the VC fund. The exogenous events of 2000, when all projects became less valuable and more delay-prone, should have differing effects on funds with different contractual provisions and on projects belonging to different industry/technology segments. We test the latter predictions on the sample of firms that experienced an exit by 2005, and look back at the decisions of the VC whether to continue financing them or to abandon. We show that VCs in general are less likely to abandon projects than other investor types, but older VCs are much more likely to do so. This effect is not found in corporate VC funds, which are not subject to a limited life span. It is not found before 2000, indicating that perhaps this issue was not considered of importance. Finally, we show that this effect is very similar for IT and life sciences firms, but is nonexistent in the non-high-tech firms. This perhaps indicates that the degree of information asymmetry between GPs (highly specialized experts) and the market is higher in the former 2 fields than in the latter.

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

Appendix. Proof of Proposition 2

1. Equilibrium with Monitoring of All Good Projects

If all good projects are monitored, then from an outsider's perspective, an unfinished project can be a bad project with probability $(1-p)(1-\lambda)$, it can be a good but delay-prone project with probability $p(1-\gamma)(1-q_L)(1-\lambda)$, and with probability $p\gamma(1-q_H)(1-\lambda)$ it can be a good project that is not delay-prone. Therefore, the probability of observing an unfinished project is $(1-pq_0)(1-\lambda)$. Using expression (4) for competitive pricing under equilibrium beliefs that all projects are continued, we find that the expected value of the project, conditional on the fact that it is not finished, is therefore

$$\pi_1 \quad = \quad V\frac{p\,(1-q_0)}{1-pq_0}.$$

The GP must prefer to monitor a project even when he observes $q=q_L$. This condition is

$$c[q_L+\lambda(1-q_L)]V + c(1-q_L)(1-\lambda)\pi_1 - m \quad \geq \quad c(1-\lambda)\pi_1.$$

Rearranging and using the notation $M = m/c$, we obtain the first condition that this equilibrium exists whenever

$$M \quad \leq \quad V\left[\lambda + \frac{q_L(1-\lambda)(1-p)}{1-pq_0}\right].$$

2. Equilibrium with No Monitoring of Delay-Prone Projects

Since monitoring in this equilibrium is continued only for good projects with a high probability of finishing at $t=2$, the probability of observing an unfinished project at $t=2$ is $1-p\gamma q_H$. The expected value of the project, conditional on the fact that it is not finished, is above 0 only when the project is good and $q=q_H$:

$$\pi_2 \quad = \quad V\left(\frac{1-q_H}{1-p\gamma q_H}\right)p\gamma.$$

Since $\gamma q_H < q_0 < q_H$, it follows immediately that $\pi_2 < \pi_1$.

We must again impose the conditions that the equilibrium beliefs are consistent with the actual strategy. The GP must prefer to monitor a project when he observes $q=q_H$, and not to monitor when he observes $q=q_L$. These conditions are

$$c[q_H+\lambda(1-q_H)]V + c(1-\lambda)(1-q_H)\pi_2 - m \quad \geq \quad c(1-\lambda)\pi_2$$

and

$$c[q_L+\lambda(1-q_L)]V + c(1-q_L)(1-\lambda)\pi_2 - m \quad < \quad c(1-\lambda)\pi_1,$$

which gives us the double inequality for M:

$$\lambda V + q_H(1-\lambda)\,(V-\pi_2) \quad \geq \quad M \quad > \quad \lambda V + q_L(1-\lambda)\,(V-\pi_2)\,.$$

Substituting the value of π_2, we get

$$\lambda V + q_H(1-\lambda)V\left(\frac{1-p\gamma}{1-p\gamma q_H}\right) \quad \geq \quad M \quad > \quad \lambda V + q_L(1-\lambda)V\left(\frac{1-p\gamma}{1-p\gamma q_H}\right). \ \square$$

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

References

Admati, A. R., and P. Pfleiderer. "Robust Financial Contracting and the Role of Venture Capitalists." *Journal of Finance*, 49 (1994), 371–402.

Aghion, P.; P. Bolton; and J. Tirole. "Exit Options in Corporate Finance: Liquidity versus Incentives." *Review of Finance*, 8 (2004), 327–353.

Benmelech, E. "Asset Salability and Debt Maturity: Evidence from Nineteenth-Century American Railroads." *Review of Financial Studies*, 22 (2009), 1545–1584.

Bergemann, D., and U. Hege. "Venture Capital Financing, Moral Hazard and Learning." *Journal of Banking and Finance*, 22 (1998), 703–735.

Casamatta, C. "Financing and Advising: Optimal Financial Contracts with Venture Capitalists." *Journal of Finance*, 58 (2003), 2059–2085.

Casamatta, C., and C. Haritchabalet. "Learning and Syndication in Venture Capital Investments." Working Paper No. 3867, CEPR (2003).

Cumming, D. J., and J. G. MacIntosh. "Economic and Institutional Determinants of Venture Capital Investment Duration." In *Issues in Entrepreneurship: Contracts, Corporate Characteristics and Country Differences*, G. D. Lidecap, ed. Oxford, UK: Elsevier Science, JAI (2003), 125–159.

Cumming, D. J., and U. Walz. "Private Equity Returns and Disclosure around the World." *Journal of International Business Studies*, 41 (2010), 727–754.

Dewatripont, M., and E. Maskin. "Credit and Efficiency in Centralized and Decentralized Economies." *Review of Economic Studies*, 62 (1995), 541–555.

Faure-Grimaud, A., and D. Gromb. "Public Trading and Private Incentives." *Review of Financial Studies*, 17 (2004), 985–1014.

Glode, V., and R. C. Green. "Information Spillovers and Performance Persistence in Private Equity Partnerships." Working Paper No. 1260952, SSRN (2008).

Gompers, P. A. "Optimal Investment, Monitoring, and the Staging of Venture Capital." *Journal of Finance*, 50 (1995), 1461–1489.

Gompers, P. A. "Grandstanding in the Venture Capital Industry." *Journal of Financial Economics*, 42 (1996), 133–156.

Gompers, P. A., and J. Lerner. "The Use of Covenants: An Empirical Analysis of Venture Partnership Agreements." *Journal of Law and Economics*, 39 (1996), 463–498.

Gompers, P. A., and J. Lerner. "An Analysis of Compensation in the U.S. Venture Capital Partnership." *Journal of Financial Economics*, 51 (1999), 3–44.

Gompers, P. A., and J. Lerner. "The Venture Capital Revolution." *Journal of Economic Perspectives*, 15 (2001), 145–168.

Hellmann, T. "The Allocation of Control Rights in Venture Capital Contracts." *Rand Journal of Economics*, 29 (1998), 57–76.

Hellmann, T. "A Theory of Strategic Venture Investing." *Journal of Financial Economics*, 64 (2002), 285–314.

Hochberg, Y. V.; A. Ljungqvist; and A. Vissing-Jorgensen. "Informational Hold-Up and Performance Persistence in Venture Capital." Working Paper No. 1260496, SSRN (2008).

Hsu, D. H., and M. Kenney. "Organizing Venture Capital: The Rise and Demise of American Research & Development Corporation, 1946–1973." *Industrial and Corporate Change*, 14 (2005), 579–616.

Kanniainen, V., and C. Keuschnigg. "The Optimal Portfolio of Start-Up Firms in Venture Capital Finance." *Journal of Corporate Finance*, 9 (2003), 521–534.

Kaplan, S. N., and P. Stromberg. "Financial Contracting Theory Meets the Real World: An Empirical Analysis of Venture Capital Contracts." *Review of Economic Studies*, 70 (2003), 281–315.

Kaplan, S. N., and P. Stromberg. "Characteristics, Contracts, and Actions: Evidence from Venture Capitalist Analyses." *Journal of Finance*, 59 (2004), 2177–2210.

Lerner, J. "Venture Capitalists and the Oversight of Private Firms." *Journal of Finance*, 50 (1995), 301–318.

Lerner, J., and A. Schoar. "The Illiquidity Puzzle: Theory and Evidence from Private Equity." *Journal of Financial Economics*, 72 (2004), 3–40.

Leshchinskii, D. "Project Externalities and Moral Hazard." In *Venture Capital: Investment Strategies, Structures, and Policies*, D. J. Cumming, ed. Hoboken, NJ: Wiley (2010), 191–219.

Litvak, K. "Venture Capital Limited Partnership Agreements: Understanding Compensation Arrangements." Working Paper, Columbia University (2004).

Malherbe, E. "Modeling Private Equity Funds and Private Equity Collateralized Fund Obligations." *International Journal of Theoretical and Applied Finance*, 7 (2004), 193–230.

Metrick, A., and A. Yasuda. "The Economics of Private Equity Funds." *Review of Financial Studies*, 23 (2010), 2303–2341.

Neher, D. V. "Staged Financing: An Agency Perspective." *Review of Economic Studies*, 66 (1999), 255–274.

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press

Phalippou, L. "Investing in Private Equity Funds: A Survey." Working Paper No. 980243, SSRN (2007).
Phalippou, L., and O. Gottschalg. "The Performance of Private Equity Funds." *Review of Financial Studies*, 22 (2009), 1747–1776.
Puri, M., and R. Zarutskie. "On the Lifecycle Dynamics of Venture-Capital- and Non-Venture-Capital-Financed Firms." Working Paper No. 967841, SSRN (2008).
Qian, Y., and C. Xu. "Innovation and Bureaucracy under Soft and Hard Budget Constraints." *Review of Economic Studies*, 65 (1998), 151–164.
Repullo, R., and J. Suarez. "Venture Capital Finance: A Security Design Approach." *Review of Finance*, 8 (2004), 75–108.
Sahlman, W. A. "The Structure and Governance of Venture-Capital Organizations." *Journal of Financial Economics*, 27 (1990), 473–521.
Yuklea, H. "VCx: An Experimental Investigation of VC Myopia." Working Paper, Hebrew University of Jerusalem (2007).

https://doi.org/10.1017/S0022109010000840 Published online by Cambridge University Press