

How Novelty Aversion Affects Financing Options

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Entrepreneurs may undertake bad projects because they unwittingly rely on defective or incomplete information to estimate the returns. Investors' concerns about such misjudgments are relatively low when the entrepreneurs' knowledge about their projects has been well calibrated. But if the novelty of the project (or some other unusual circumstance) makes calibration impossible, investors may reject the entrepreneur's funding request. This 'novelty aversion' effect helps explain why ventures that are initially self-financed can subsequently attract outside financing without any decrease in standard 'incentive' or moral hazard problems. It also provides new insights about the differences in the investment preference and procedures of individual 'angel' investors, venture capital partnerships and large public companies.

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1. Introduction

In 1990 two professors of economics, Carl Case and Robert Shiller, and one of Shiller's students, Allan Weiss, tried to start a business that would help create a futures market in real estate by providing indexes for contract settlement. They approached Corning Capital and Canaan Venture Partners for start-up financing but were turned down. Case, Shiller and Weiss then financed their eponymous firm through personal savings and borrowings. There were no outside investors in Case Shiller Weiss, Inc. until its acquisition in 2002 by a publicly traded financial services company.

Principal-agent models usually trace the problem faced by entrepreneurs in raising capital to concerns about their truthfulness and incentives. For instance, Leland and Pyle (1977) suggest that access to outside financing will depend on the willingness of entrepreneurs to truthfully reveal their 'type' by investing their own capital. But the founders of Case Shiller Weiss, Inc. did in fact invest their capital and indeed took out second mortgages on their homes. Moreover, we should expect concerns about truthfulness and incentives to have been more severe in 2002 – when the founders potentially had more adverse information to conceal (and were selling their entire stake) than in 1990 when the business plan was based on beliefs rather than hard data (and the founders had powerful incentives to make the venture a success).

An alternative explanation is that entrepreneurs cannot raise capital because investors are concerned about what could be called honest mistakes. Many investors apparently follow Napoleon's dictum: 'Never ascribe to malice that which can be adequately explained by incompetence.' For instance, professional venture capitalists (VCs) summarily reject most of investment proposals without even considering the possibility of misrepresentation or misaligned incentives. And for proposals that they seriously consider, VCs don't just try to uncover facts that entrepreneurs have an incentive to conceal, such as a criminal record. VCs also investigate projections (for instance, about technologies and markets) that entrepreneurs make in good faith.

But what kinds of errors might Messrs. Case, Shiller and Weiss make that would cause investors to reject their funding request? Hammond (1996) distinguishes errors of 'coherence' – failing to conform to rational standards – from errors of 'correspondence' – estimates that deviate from true probabilities. Errors of coherence can arise from a variety of reasons. First, as most people who have taken exams know, an individual's raw brain power may not be adequate to perform a particular intellectual task. Second, even individuals who have the necessary mental

capacity may occasionally slip up especially if they are under time pressure. These random mistakes have been modeled in papers by Sah and Stiglitz (1986, 1988) and Sah (1991).

Third, errors may arise because of cognitive biases and illusions. Behavioral economists have done extensive research on how such biases affect the pricing of securities. Research on their effects on entrepreneurial behavior has also begun to emerge. For instance, in the Landier and Thesmar (2003) model ‘over-optimistic’ entrepreneurs suffer from ‘base rate neglect’ – they observe that an idea has promise but ignore the rate at which promising ideas fail.

It seems implausible however that Messrs. Case, Shiller and Weiss of all people would have a greater propensity to commit errors of coherence than the entrepreneurs who did receive funding from the investors they had approached. Few founding teams have the same intellectual capacity or the training in avoiding errors such as base rate neglect. Shiller has in fact been at the forefront of research in behavioral finance and his popular reputation is not that of a congenital optimist.

But even rational entrepreneurs may commit what Hammond calls errors of correspondence. For instance, there is no reliable record of the rate at which promising ideas fail. Indeed the commonly cited statistic that nine out of ten start-ups (which presumably include a great many unpromising businesses) fail appears to have a dubious provenance. So Messrs. Case, Shiller and Weiss would have had to make a highly subjective guess about the rate at which ideas with the same level of promise as their venture fail. Similarly, their estimates of the size of a futures market in residential real estate – if they succeeded in creating one – would also require subjective judgments. And if the prior knowledge used to form these judgments was in some way deficient, their estimates, although formed in a completely rational way, would be in error.

I argue that concerns about deficiencies in the knowledge entrepreneurs use to form their judgments lead investors to discount the entrepreneurs’ expectations of returns. Moreover, the magnitude of this discount increases with the novelty of the project or situation about which the entrepreneurs form their judgments, because novelty precludes calibration of the entrepreneurs’ knowledge. For instance, this ‘novelty aversion’ effect suggests that Messrs. Case Shiller and Weiss would have had more success in raising outside capital if they had tried to start a mutual fund instead of trying to create a market for futures in residential real estate. It also helps explain why they were able to sell their firm in 2002 even though information asymmetry and incentive problems were probably more severe at that time than in 1990.

Novelty aversion also helps explain differences between the investment procedures and choices of professional VCs and individuals like the so-called venture angels who invest their

own funds. It suggests that venture angels are more likely to invest in start-ups like Case Shiller Weiss, Inc. than are professional VCs.*

2. Concerns about biased estimates

Individuals routinely commit errors of correspondence because of wrong or incomplete knowledge. For instance, before the early 1990s physicians didn't know that many peptic ulcers resulted from bacterial infections; rather, they attributed the condition to poor diets or stress. As a result they underestimated the benefits of using antibiotics and overestimated the efficacy of histamine-2 blockers and the avoidance of spicy foods.

Concerns about deficient knowledge do not necessarily affect principal agent interactions if all agents have the same information. Before Warren and Marshall published their research linking *helicobacter pylori* to peptic ulcers, it wouldn't matter which physician a patient went to – no one would think of prescribing antibiotics. Now too it doesn't matter because most physicians know that bacterial infections can cause ulcers.

Principals' concerns about biases in agents' judgments however come into play if the judgments are based on 'idiosyncratic' rather than 'common' knowledge. Consider for instance the period between the early 1980s when Warren and Marshall had just published their research and the early 1990s before the findings had been widely replicated and disseminated. During this period some physicians prescribed antibiotics while others did not. Physicians in the latter category were not necessarily less rational, or even unaware that some of their colleagues had started prescribing antibiotics – they simply may not have seen the same research as the early adopters.

But what might lay-patients who knew nothing about the traditional theories or the new research have thought about the differences in treatments offered by physicians? If patients believed that both the early adopters and the skeptics were rational, didn't have a private ax to grind, and were equally likely to have the right information, patients would infer that the early adopters had overestimated the probability that bacterial infections cause peptic ulcers while the skeptics had underestimated this probability.

Similarly, suppose an individual today (who does not have a PhD in finance) is deciding between investing in an index fund or an actively managed 'value' fund. To make this choice the individual reads the finance literature and finds that in spite of extensive recent research scholars

* I formulated my hypotheses through an inductive process after finding that theories based on concerns about dishonesty and conflicts of interest did not persuasively explain why some entrepreneurs receive funding while others do not. I then found that Van Den Steen (forthcoming) has independently formalized propositions similar to some of the hypotheses discussed in this paper.

with impeccable credentials continue to disagree on the degree to which the stock market is efficient. A reasonable person will likely infer that that the average estimate of the contending parties must be right; therefore, scholars like Fama and French are likely to have overestimated the efficiency of stock markets while behavioral finance skeptics have underestimated market efficiency.

We can distill the essence of these examples by imagining two agents who form different estimates because they have different information (like the early adopters and skeptics of antibiotic treatments) or because they have different priors (presumably like the believers in highly efficient markets and behavioral anomalies). A third party – the ‘principal’ – like the typical patient with a peptic ulcer, has diffused (or ‘informationless’) priors. Therefore the principal makes the Solomonic inference that the true estimate lies somewhere between the estimates of the two agents. This naturally means that from the principal’s perspective one agent’s estimate is too high and that the other agent’s estimate is too low.*

3. Investor-Entrepreneur Interactions

An example. In a fund raising situation, the principal may see the estimate of just one agent who wants financing for her project and assume the existence of another agent in whose judgment the same project was unattractive. Accordingly, the principal assumes that estimate he sees is too high (and the estimate he doesn’t see is too low). To illustrate, consider the following example, which is loosely based on the efforts of Howard Schultz (the founder of Starbucks) to start a chain of espresso bars in 1987. An entrepreneur is entranced by the espresso bars she encounters in Italy and contemplates opening one in her home-town of Seattle where she has never observed an Italian style espresso bar. After studying many Italian bars and some introspection she concludes that in contrast to Italy where espresso bars flourish everywhere, they would almost certainly fail in most Seattle locations; however starting a bar in a prosperous neighborhood in Seattle would have a positive expected value.

In forming this judgment the entrepreneur does consider the possibility that another individual might previously have investigated and then rejected the opportunity to start espresso bars in prosperous Seattle neighborhoods. However she believes it more likely that her predecessor did not observe the success of espresso bars in a place like Italy rather than that the predecessor found a compelling reason for why an espresso bar in Seattle would fail.

* The principal’s discount of the high estimate can be regarded as the “choice driven over-optimism” formalized in Van Den Steen’s (forthcoming) Proposition 1.

Suppose the entrepreneur then approaches a wealthy investor in Seattle for some of the money she needs to start an espresso bar. The entrepreneur reveals everything she possibly can and the investor does not question her rationality, truthfulness or motives. But the investor who has highly diffused priors – he has never been to an espresso bar or traveled to Italy – places more weight on the prior unobserved rejections than the entrepreneur has done and therefore ‘shades down’ or discounts the entrepreneurs projections.* The magnitude of this may depend on factors such as the quality of the entrepreneur’s presentation, whether the investor has an optimistic disposition and his estimate of how many other entrepreneurs might have previously rejected the opportunity. Although an examination of these factors could be a topic for further research, this lies outside my focus. Here it is sufficient to note that if the discount is sufficiently large the investor will turn down the entrepreneurs funding request.

Novelty Aversion. Notice that the entrepreneur consciously makes a significant inductive leap from her observations about espresso bars in Italy to the expected return of espresso bars in Seattle – her estimate is uninformed by data about the actual returns in Seattle because the project is extremely novel. Nor does she expect that the same ‘model’ can accurately predict the distribution of returns in Italy and Seattle. Now consider the following wrinkle. As before, the entrepreneur first estimates returns based just on her Italian research and introspection. But then after returning to Seattle, she discovers that her idea isn’t totally novel – other entrepreneurs have previously tried to open espresso bars in prosperous neighborhoods in her hometown. She uses the data about these Seattle espresso bars to calibrate her subjective initial estimate before asking the investor for funds. The more data she has available about previous attempts (i.e. the less novel her project), the lower the discount investors will apply to her estimates.

To make this a little more concrete, suppose that after her Italian research the entrepreneur estimates that the probability that espresso bars started in prosperous Seattle neighborhoods will be successful follows a beta distribution with parameters s and $n - s$ and mean value of $p' = s/n$. After returning home, she finds that other entrepreneurs have started N bars in prosperous neighborhoods in Seattle of which S have been successful. This data leads her to update her estimate in accordance with Bayes rule. So her posterior estimate has a beta distribution with parameters $s+S$ and $(n+N) - (s+S)$, and a mean $p'' = (s+S)/(n+N)$.

* We might say that the investor anticipates a lemon problem, but with a twist. In the classic Akerlof setup, buyers worry that only those owners who have adverse information about their goods will offer them for sale. Here the investor worries that the entrepreneur does *not* know about adverse information that her predecessor had uncovered.

As previously argued, investors believe that the entrepreneur's estimate of p' is too high. Investors do not however question its subsequent calibration – like the entrepreneur the investors believe that the N observations represent a random sample from the distribution whose parameters are being estimated. Therefore, from the investors' point of view:

- the entrepreneur's preliminary estimate p' should have been $(s - e)/n$ (where $e > 0$) instead of s/n ; and,
- After observing S out of N successes, the entrepreneur should have formed a posterior estimate $p'' = (s - e + S)/(n + N) = (s + S)/(n + N) - e/(n + N)$ instead of $(s + S)/(n + N)$.

Notice that the bias investors' expect in the entrepreneur's posterior estimate, namely $e/(n + N)$, decreases as N increases. When N is small and investors anticipate a large bias, their minimum required rates of return conditional on success will also be much greater than the entrepreneur's minimum rate. Therefore, proposals whose projected returns (conditional on success) lie between these investors' and entrepreneur's minimums will face rejection. When N is very large however (i.e. the entrepreneur has lots of data on the success rates of Seattle espresso bars) the anticipated bias will be very small. In this instance, the difference between the two sets of cutoff rates will disappear and any project proposed by the entrepreneur will be acceptable to the investors.

Investor's knowledge and research. I assumed that the investor had diffused priors about the prospects of an espresso bar in Seattle. It is possible that an investor who had previously been to Italy and had fallen in love with the espresso bars there could be more optimistic about the prospects of an espresso bar in Seattle than the entrepreneur herself; the lack of calibration of the entrepreneur's estimate would then not impede her fund raising efforts. If, on the other hand, an investor had pessimistic priors about the chances of getting people in Seattle to start paying large sums for small amounts of coffee, their novelty aversion would be more severe.

I also assumed that investors made no effort to do their own research on espresso bars in Italy. What if they were willing to do so? This wouldn't make a difference to my argument as long as the investors' information gathering efforts involved costs: the decision to 'invest' in research involves the same kinds of trade-offs as the decision to invest in the project itself.

Other investor concerns. Concerns about truthfulness and incentives that have been emphasized in many principal-agent models may impede fund raising but do not directly lead to a bias against novelty. Suppose that investors are concerned just about the entrepreneur's honesty or the pursuit of private benefits. Then investors will examine the entrepreneur's overall track record for evidence of past dishonesty or the likelihood that a particular project will provide large private benefits to the entrepreneur. This examination too does not involve any direct bias against

novel projects – an entrepreneur with a dubious record will have difficulty raising capital for all kinds of projects. Similarly, suppose investors are concerned about overestimates that result from the entrepreneur’s overall reasoning capacities (e.g. base rate neglect in the Landier and Thesmar model). Then the investor will examine the entrepreneur’s track record to assess whether she knows that that base rates matter or if she has an excessively optimistic disposition. But track records that provide reassurance about the entrepreneur’s overall reasoning ability may derive from any domain. Therefore, the entrepreneur’s generic inexperience – the absence of a *general* track record – rather than the novelty of her specific proposals will impair her ability to raise outside capital.

The degree of the investors’ novelty aversion may however vary with their assessment of the entrepreneur’s overall disposition. Suppose for instance investors’ believe that a particular entrepreneur has an inherently optimistic disposition or that she tends to form ‘strong’ preliminary estimates. Such an entrepreneur would then have to provide more data about similar prior occurrences to support her proposals than an entrepreneur who investors believed was less optimistic or formed weaker estimates.*

Manifestations of novelty. Where Ecclesiastes declared that there is nothing new under the sun, Heraclitus asserted that it is impossible to step into the same river twice.† My argument incorporates both viewpoints. It obviously requires that entrepreneurs examine novel projects about which they have to make idiosyncratic judgments. These judgments may be informed by observations of similar but not identical past situations – the entrepreneur has to make a subjective adjustment for some unprecedented circumstance. I also need entrepreneurs and investors to treat some observations as random draws from a stationary distribution. If they regarded everything as unprecedented, the calibration that is also essential in my argument to assuage the concerns of investors’ about bias would not occur.

That said, the ‘novelty’ that I refer to has pervasive manifestations. So far I have just used examples involving a high level of innovation – the efforts to create a market for residential real-estate futures; dramatically change the treatment for peptic ulcers; and, bring the concept of high-end espresso bars to the U.S. But I did this only to dramatize my argument. In fact the novelty that, according to my hypothesis, leads to financing problems does not require the

* In the illustrative example investors would adduce a large value of e for an optimistic entrepreneur. Their estimate of the entrepreneurs posterior error $e/(n + N)$ would also be large, so it would take more N to effect the same reduction in the investors’ estimates. Similarly, we can represent an entrepreneur who forms ‘strong’ preliminary estimates as someone whose estimates of ‘ s ’ and ‘ $n - s$ ’ tend to be large. Here too the same reduction in the investors’ estimates of the entrepreneur’s posterior bias would require more N .

† From the Columbia World Book of Quotations 1996.

introduction of a totally new technology, product or service. For instance, the opening of a high-end restaurant is an oft-repeated occurrence. Yet each such occurrence is to a considerable degree unique – we can see a great deal of variation in menus, décor and location in addition to the intangible differences in the atmosphere that the proprietor creates. Thus, estimates of the probability that a new high-end restaurant (as opposed to a now standardized McDonalds or Starbucks outlet) will be successful involve an un-calibrated judgment.

The unusual absence of information can introduce novelty into otherwise mundane settings. Suppose that in our espresso bar example the entrepreneur develops a well calibrated estimate of the probability of success in prosperous neighborhoods, using average local rents to determine whether a neighborhood was prosperous. If information about rents happened to be unavailable for a particular location, the entrepreneur might use some other yardstick (e.g the number of BMWs parked on the streets) to determine whether the neighborhood is prosperous. But the entrepreneur cannot offer any data about the calibration of this modified procedure because unobtainable values of rents would represent a ‘novel’ condition.

Investors may also treat proposals as novel if the entrepreneur tries to replicate an estimation procedure involving ‘tacit’ knowledge (Polanyi 1962). For instance, suppose an entrepreneur has a well calibrated estimate of the probability of success of an espresso bar in a prosperous neighborhood, but that her determination of ‘prosperity’ involves the use of tacit knowledge that she cannot easily communicate to anyone else. A second entrepreneur might conclude that a certain neighborhood is prosperous when the first entrepreneur might not. If the second entrepreneur’s funding request relies on the first entrepreneur’s estimate, investors will not regard the estimate as well calibrated.

Evidence. Investor skepticism about entrepreneurs’ estimates of the returns of novel projects provides a more plausible explanation than do standard principal-agent theories of the widespread occurrence of self-financed businesses that subsequently raise outside capital.

Some self-financed start-ups are low-growth sole-proprietorships that do not require much capital. But self-financing is also common in high-growth businesses. For instance, Bhidé (2000) studied 100 businesses formed between 1981 and 1983 that appeared on *Inc.* magazine's list of the 500 fastest growing privately held companies in the United States. The companies in his sample recorded a more than eighteen-fold median increase in revenues between 1984 and 1988 and more than an eight-fold increase in employees. Of these ventures, 80% were financed principally by the founders' personal savings and borrowings; another 8% relied on the family and friends of the founders as their principal source of funds; only 12% used funds provided by arm's length individual investors or professional VCs.

The data also suggests that the founders' capital often represents a form of 'bridge financing' – many start-ups that are initially self-financed subsequently do raise outside equity. For instance, about three quarters of the *Inc. 500* companies surveyed by Bhidé (2000) used 'follow on' debt and equity financing from outside investors to finance their growth.

Standard moral hazard theories do not easily explain these patterns. The Leland and Pyle (1977) model, for instance, suggests that the unwillingness of entrepreneurs to commit their capital makes it difficult to secure outside financing because it signals that entrepreneurs have adverse private information about their ability. But self-financed entrepreneurs do invest their own capital – sometimes to a greater degree than entrepreneurs who secure outside financing. For instance, Sandy Lerner and Len Bosack, the founders of Cisco, could not secure outside financing, in spite of committing all their savings and taking out large personal loans. In contrast Jim Clark easily raised VC financing for WebMD and Healthon while committing only a portion of his wealth to these ventures.

Similarly, the "stealing theories" reviewed by Kaplan and Stromberg (2000) suggest that the availability of capital for a start-up depends on the observability and verifiability of an entrepreneur's effort. Entrepreneurs who start businesses where they can secure 'private benefits' at the expense of their investors in a manner that investors cannot easily detect or prove in a court of law face more significant capital constraints. This does not offer a plausible explanation for why the founders of companies like Compaq, Lotus and Juniper Networks financed their start-ups with outside equity when the founders of its direct competitors, Dell, Microsoft and Cisco, did not.

More crucially, moral hazard or adverse selection problems do not easily explain why entrepreneurs who cannot raise funds to start their ventures can subsequently raise outside funds to finance growth. It seems unlikely that the founders of Cisco, who had to self-finance their start-up in 1984, could raise capital from investors in 1987 because investors' concerns about lying, inadequate effort, or the pursuit of private benefits declined. If anything, we should expect such concerns to increase in the later stages of a business where entrepreneurs have greater opportunities and incentives to misrepresent the value of company assets and to slack off. And if entrepreneurs can get later-stage financing without any decrease in moral hazard or adverse selection problems, such problems cannot provide a plausible explanation for their inability to raise start-up funds from investors.

Investors' aversion to novelty (broadly defined) provides a plausible alternative explanation for the financing constraints faced by many start-ups. Entrepreneurs fail to secure outside financing because their track record in undertaking 'similar' projects simply doesn't exist,

rather than because investors are concerned that the entrepreneur is hiding adverse information. Therefore entrepreneurs have to rely on their own capital, perhaps by scaling back their projects to fit their wealth constraints. Later, as more information about their capabilities and projects becomes available (i.e. ‘novelty’ declines), entrepreneurs have less difficulty raising capital even if moral hazard problems also concurrently increase.

This explanation conforms to Bhidé’s (2000) findings about high-growth (and mainly self-financed) start-ups. At the outset, there was very little question of investors suspecting founders of hiding information about whether their businesses would survive or the returns they would earn if they survived. No one had much information. The founders did not start out with proprietary ideas or valuable intellectual property whose value a prospective investor could assess in advance. Only 6% claimed to have started with unique products and services and only 3% had patents. Many founders also did not have deep business or industry experience and lacked ex-ante information about factors (such as their capacity to persuade customers to purchase undifferentiated products from an undercapitalized start-up) that seemed to play a significant role in the subsequent performance of their business.

The founders did not devote many resources to research or planning either; apparently they obtained critical information about markets, competitors and even their own abilities after starting their ventures. And given the circumstances it is hard to imagine how they could have done such research – they had to rely on a highly subjective estimate.

4. Venture Capitalists versus Angels

I had suggested in the introduction that founders of businesses like Case, Shiller and Weiss are more likely to secure funding from the so-called ‘venture angels’ who make their own investment decisions than from professional VCs who make investments on behalf of the ‘limited partners’ who provide them with capital. Why might this be so?

Stylized facts. Prior research and casual observation suggest systematic differences between VCs and angels: VCs receive a very large number of funding requests from which they select a very small number of projects. Historically, VC firms have provided start-up financing to less than one percent of new businesses formed in the United States each year. This is not because the number of proposals made to VCs is low; rather VCs receive a great many funding

requests from which they make a very small number of relatively large – of the order of several million dollar – investments.*

VCs make more than 80% of their investments in information technology and healthcare ventures – in total, these two sectors, according to OECD and U.S. Department of Commerce estimates, represent less than 20% of U.S. G.D.P. The criteria that VCs use to select investments vary by firm, but most VCs have a strong preference for start-ups that serve large and growing markets rather than unproven niche markets that may or may not grow. For instance VCs didn't invest in any personal computer software companies (like Microsoft and Visicalc) started between 1975 and 1982; subsequently, after the potential market for software had been well-established, they financed companies like Lotus and Intuit. Similarly nano-technology has been much talked about for well over a decade – I supervised an MBA study on its prospects in 1991. But to date, VCs have invested only a tiny proportion of their capital in that field.

VCs avoid businesses started by inexperienced founding teams and favor 'later stage' investments. The National Venture Capital Association's annual report shows that in 1996, 77% of companies receiving VC funding were three years old or older. Subsequent annual reports (which do not report the ages of companies receiving VC funding) classify only 22% of total VC disbursements in 1999, and 23% in 2000, as 'early stage.'

Venture angels apparently conduct less extensive due-diligence and use less stringent criteria than do VCs. Freear, Sohl and Wetze (1995) report that a median time span of 2.5 months elapses between an angel's first meeting with an entrepreneur and the receipt of funds. The equivalent time for comparable VC investments is 4.5 months. Angels are more willing to provide capital to inexperienced entrepreneurs and to 'pre-revenue' businesses with unproven markets and technologies (Freear, Sohl and Wetze 1992, Wong 2002). Overall, Freear et al. (1992) estimate that angels finance ten times as many businesses as do VCs.

Researchers such as Gompers (1995) and Amit, Brander and Zott (1997) suggest that the *raison d'être* of VCs lies in their ability to solve information asymmetry problems. As Kaplan and Stromberg (2002) observe, however, tests of this hypothesis have been indirect. For instance, Gompers shows that VCs concentrate investments in "high technology industries" where he (like Amit, Brander and Zott) assumes that "informational asymmetries are highest." Gompers seems to rely (although he doesn't explicitly state this) on the low debt ratios and high irreversibility of investment to justify the assumption of severe information asymmetries in high technology

* For instance (according to its managing partner) Highland Capital Partners – a typical top-tier VC firm with about \$1.8 billion in committed capital – receives about 10,000 'qualified' business plans a year, has a 1000 follow-up meetings and 400 company visits before making about 10-20 new investments.

industries. But Gompers's data also suggests that VCs avoid the restaurant industry. And there is no evidence – direct or indirect – that the information asymmetry problems involved in starting a restaurant are materially different than in high-technology start-ups. Furthermore the asymmetric information framework does not easily explain why VCs are less willing than angels to finance inexperienced entrepreneurs, businesses serving unproven markets, and early stage projects. Gompers, for instance, only compares VCs to commercial banks.

Theories based on information asymmetry or incentive problems also do not address why VCs use more protracted and well-structured procedures to evaluate investments than do venture angels. There is an obvious nexus between the higher minimum investment thresholds of VCs and the higher fixed costs of their evaluations. But why don't we see at least some VCs adopt the streamlined procedures of credit card and equipment leasing companies to make smaller investments in many start-ups? And why might VCs require 'harder' information? According to Stein's (2002) incentive based model, hard rules protect subordinates from "winner picking" by their bosses. The model only however applies to hierarchies, where the 'boss' is also an agent rather than a principal. It cannot explain the use of hard rules by VCs which are flat organizations that receive irrevocable commitments of capital from their investors.

Could it be that angel investors are just friends and relatives who provide funding (without doing much research) for emotional reasons or because they have access to better information about the entrepreneur's true ability than do VCs? This may sometimes be true, but many angels are cashed-out entrepreneurs (Sohl 1999). Like VCs, angels often have no prior relationships with the entrepreneur; indeed according to Andrew Wong's interviews (reported to me in personal correspondence) and my own subsequent conversations with them, VCs sometimes pass on investment opportunities they consider "immature" to angel investors.

VCs as agents. My explanation for why VCs are more likely to avoid untested business models turns on the concerns of the limited partners (who invest in venture capital funds) about the judgments of VCs. As discussed, potential investors worry that even honest, reasonable entrepreneurs will overestimate the returns of their projects. The same logic suggests that limited partners will also be concerned that individuals who solicit capital for venture funds will have overestimated their capacity to pick good investments (whereas individuals who contemplate but decide against becoming VCs will have underestimated this capacity).

Furthermore the limited partners' concern extends beyond just the general intelligence or business judgment of the individual soliciting funds. Just as patients with peptic ulcers worry about their physician's capacity to treat their specific ailment and investors in espresso bars worry

about the promoters' judgment about espresso bars, limited partners worry about whether VCs are well-informed about the specific domains in which they will make investment judgments.

VCs can mitigate concerns about their domain specific expertise by providing a record of their past investments in the domain. That record is of little value however, if VCs subsequently invest in domains where they don't have well calibrated expertise. Therefore, just as the promoter of an espresso bar has to commit not to use the money she raises for some other venture, VCs make explicit or implicit commitments to invest in spheres where they have well calibrated expertise. For instance, VCs trying to raise money for a health care fund will highlight the prior experience in the field of health care and will promise to restrict all or most of their investments to health care ventures.*

These commitments discourage VCs from financing 'novel' proposals that fall outside their 'normal' past experience: a health care fund is not supposed to invest in espresso bars in Seattle. And in fact, if the espresso bar is so innovative that it falls outside all prior investment boxes, no VC fund can invest without breaching its commitment to investors. In contrast, a venture angel may also choose to concentrate on health care investments in order to build expertise or a network, for instance. But the angel is also free to deviate from this self-imposed focus. He may choose for instance to invest in an innovative espresso bar because he believes that the expected return more than compensates for any dilution of his focus and lack of expertise. And entrepreneurs can try to reduce the angel's skepticism by providing a lot of information. For instance, after approaching 242 potential investors, Howard Schultz raised \$1.7 million to finance his first espresso bars by providing videotapes and other data about such bars in Italy.

In addition to their ex-ante commitments, VCs also have concerns about creating track records that will help them raise new funds in the future. These concerns further encourage VCs to favor routine proposals over proposals that are, at least from the point of view of the VC, novel. For instance, a successful investment in an espresso bar does not help VCs who focus on health care ventures raise their next fund. Indeed, investing in an espresso bar (even if it does not violate a legal commitment to the limited partners) raises concerns about the VC's tendency to deviate from the domain in which the VC has well calibrated expertise.

We can thus think of the two principal-agent relationships in VC investments (in contrast to the single relationship in angel investments) as creating the following tradeoff: Pooling the funds of many principals provides well known advantages in mobilizing capital for large projects;

* The so-called "knock-out" funds offer investors the additional protection of being able to turn down specific projects. Such funds however have drawbacks (which I will not discuss here) that have made them unusual.

the extra layer of agency relationship also however adds another layer of novelty aversion. Moreover, this additional layer of novelty aversion is ‘unpriced’ – instead of demanding a higher return for proposals that fall outside their normal domain, VCs tend to reject them outright. This trade-off explains why we often find VC financings follow angel financings – as a venture matures, its capital requirements increase and novelty decreases.

Notice that VCs would not have to make commitments or face incentives that limit the novelty of their projects if limited partners were concerned only about the overall abilities or dispositions of agents. If investors were only concerned about general ability, they would select agents with good overall track records and would have no interest in limiting the kinds of projects the agents could select. Similarly, suppose investors were only concerned about the honesty of the agent. The restrictions that investors concerned about honesty might impose (e.g. prohibiting agents from financing the proposals of family members) would also not have a direct effect on the novelty of agents’ selections.

Screening procedures. Angel investors who finance more novel projects will make decisions more quickly simply because there is less research they can do about customers, competitors and so on. For instance, when Howard Schultz approached wealthy investors in Seattle in 1987 to finance his first espresso bars, the data that the investors could have gathered or analyzed was quite limited compared to the data available to VCs who, some years later, financed the expansion of Schultz’s chain to the Midwest.*

Efforts to assuage the concerns of limited partners also encourage VCs to rely on ‘hard’ well codified criteria to screen proposals rather than rules that involve tacit or personal knowledge. When VCs try to raise capital for a new fund they often face questions about the process they have used to compile their track records. This is because the limited partners want to ascertain that the VCs past success is based on skill rather than pure luck and whether the skill is likely to produce the same results in the future as it did in the past. VCs can more easily communicate hard decision rules (e.g. ‘only consider proposals for espresso bars if average rents in the neighborhood exceed \$30 per square foot’) than soft rules (‘only consider proposals for bars located in prosperous neighborhoods’). Furthermore, limited partners are more likely to

* Interestingly both Schultz and the VCs turned out to be wrong in their belief that the formula which had been successful for Starbucks in Seattle would also work in Chicago. According to my interview with a VC whose firm invested in Starbucks, no one anticipated that in the winter, Chicagoans would only walk short distances for a coffee – a problem that was ultimately solved by locating stores in densely populated areas. But the ‘novelty’ involved in the Mid-Western expansion was a surprise. Ex-ante Schulz and the VCs believed that the Starbucks model had been well calibrated in the Pacific Northwest.

regard a track-record based on hard rules as a sample from a 'stationary' distribution (such that the VCs past performance provides a more accurate predictor of future performance).*

The preference for hard rules helps explain why VCs tend to invest in high technology ventures rather than restaurants. The evaluation of plans for new restaurants involves the assessment of subjective variables, whereas the prospects of high technology ventures (of the sort that VCs favor) can be assessed through objective analyses of patent filings and the price-performance of competing technologies. Similarly, VCs favor proposals from entrepreneurs with proven experience and avoid taking a chance on the innate potential of inexperienced founders. Angel investors too may prefer experienced to inexperienced founders, but if the terms are sufficiently attractive they will tend to be willing to make a subjective bet on the inexperienced founders.

VCs may also devote more effort to solving asymmetric information problems than do angel investors. This does not mean that VCs seek out (as Gompers and others apparently suggest) ventures with information asymmetry problems the way pawnbrokers and the so-called sub-prime lenders target individuals with impaired credit histories. Kaplan and Stromberg's (2002) empirical data (and my propositions) suggest that the causality runs in the opposite direction. Kaplan and Stromberg show that VCs use criteria that lead them to avoid 'novel' projects and situations where no one has much information. This bias likely leads VCs to undertake projects where they face more severe information asymmetries. For instance, the experienced entrepreneurs that VCs favor are more likely to have adverse evidence about their true capabilities that they wish to conceal than inexperienced entrepreneurs (who have no track record, good or bad). Similarly, entrepreneurs who seek later stage financing have lower incentives to make truthful forecasts and maximize effort than entrepreneurs who seek seed funds and face the prospect of more financing rounds. Therefore, VCs may devote more effort to checking references, monitoring, and aligning incentives.

5. Large corporations versus VCs

Instead of trying to start their own business, Messrs. Case, Shiller and Weiss could have tried to sell or license their know-how to a large corporation. But the evidence suggests that decision makers in large companies are even more reluctant than VCs to invest in untested new technologies. Stanford University, for instance, assigned the rights to a workstation technology to Andrew Bechtolsheim, a graduate student who had been developing the technology, after

* The same preference for hard rules incidentally is commonly observed among individuals and institutions who select managers to invest in publicly traded securities.

established computer companies showed no interest. Bechtolsheim licensed the technology to several VC-backed start-ups. Eventually he contributed it to Sun Microsystems (that was also VC-financed) where he became a co-founder (Bhidé 1989).

This is not an isolated case: Shane's (2001) study of MIT's technology licensing suggests that new firms are more likely than existing firms to license a novel technology. Similarly, Kalamas, Pinkus and Sachs (2002) argue that deals by large pharmaceutical companies to license new drugs from bio-technology companies "are often struck too late to generate maximum value." Only a third of deals occur in the preclinical stage; according to Kalamas et al.'s simulations, this proportion reflects "overdiscounting for the uncertain prospects of deals made early in the development process."

According to Bankman and Gilson's (1999) model, large firms cannot provide adequate incentives for all employees to develop their ideas within the firm, so some leave to start new firms. But Klepper's (2001) evidence suggests that employees often start businesses after their employers have rejected their projects. Bankman and Gilson's model also does not explain why large companies prefer to license more mature technologies.

The Stein winner picking model does provide an incentive based explanation. Although it does not explain why there should be any difference in the use of hard rules by VCs and angel investors, it does predict that large hierarchical corporations will use hard rules more extensively than will VCs. As previously discussed, hard rules discourage investments in highly novel ventures where there is little objective data available for analysis.

But should we treat the winner picking model as our explanation of first resort? Certainly the prediction that hierarchies rely on harder rules than flat organizations is consistent with common observation and has been corroborated by empirical research, for instance, by Berger et. al (2002). In my case research I have also observed that as small firms evolve into large firms they become more hierarchical and adopt hard rules (Bhide 2000). I have never however met a decision maker who cited winner picking problems as a reason for making such changes. And I don't believe that this is because I observed a skewed sample of firms. More likely, it is because in winner picking models large firms comprise many smaller subunits whose managers compete for capital allocated by the CEO. But usually as firms grow, they seek to exploit complementarities or synergies across their component units. This requires managers to collaborate rather than compete to secure capital for their independent projects. Even after firms have become very large their CEOs keep trying, in spite of obvious difficulties, to exploit complementarities and promote collaboration between their subordinates. Large firms managed as pure conglomerates are rare.

My explanation focuses on the efforts of large firms to realize complementarities through the purposive coordination across different sub-units. Such efforts favor the evaluation and planning of projects by large teams. Conversely after procedures to evaluate projects through large teams have been established, the firms tend to specialize in projects where complementarities offer benefits commensurate with the higher decision making costs incurred by large teams. The launch of IBM's Personal Computer in 1981 illustrates the evaluations and projects I have in mind. According to Cringely (1992) when Bill Lowe, head of IBM's Entry Systems Division, proposed that IBM enter the personal computer business in 1980, Lowe had to navigate many layers of the IBM hierarchy and ultimately persuade the members of the Corporate Management Committee. The launch itself required the coordination of activities ranging from hardware and software design, licensing (of the operating system and the likeness of Charlie Chaplin's character from *The Little Tramp*), development of ISV (Independent Software Vendor) and office product dealer networks, training and deployment of the in-house sales force and a national advertising campaign.

VCs use much smaller teams to evaluate their projects and the success of these projects does not turn on the realization of complementarities to the same degree. For instance, when US Venture Partners (USVP) evaluated a proposal to provide seed financing to Sun Microsystems in 1981, the firm comprised just three general partners. Sun's founders made their case to a single partner, Robert Sackman (Bhidé 1989). Sackman then persuaded the founding partner, Bill Bowes; this secured a two-thirds majority of USVP's general partners in favor of the investment (personal correspondence with Bowes). And, in its early years Sun focused on a few functions – hardware design, enhancement of the UNIX operating system and direct sales and support. Sun did not have any large scale manufacturing and did not develop a dealer network or mount public relations or advertising campaigns (Bhidé 1989).

Stockholders' reliance on a 'thick' layer of decision-making agents also increases the novelty aversion of large firms. As argued in the previous section, the concerns of their limited partners encourage VCs to reject novel projects that fall outside their prior sphere of investment expertise. Large corporations employ many agents whose collective knowledge spans many fields, but whose joint sphere of prior expertise is narrow. Restricting the team to its well-calibrated domain of expertise involves a broader sphere of forbidden novel projects than is the case with VC firms.

Consider for instance VC firms that focus on health care ventures. As mentioned, such VCs will usually not finance innovative espresso bars regardless of the personal beliefs of the individuals running the fund. But, the range of ventures that a health care VC will consider,

especially for later stage investments, is quite broad. For instance, the current portfolio of Tullis-Dickerson – a health care focused VC firm with just five principals – includes companies engaged in developing or providing drugs for respiratory disorders; devices and materials used by surgeons; therapeutic proteins; bio-image analysis; disease management services to managed care organizations; information management software for the behavioral health market; clinical research services; and individualized elder care services. In contrast, the project portfolios of large pharmaceutical companies like Merck and Pfizer are much more tightly circumscribed.

Notice that this argument applies to firms that use large decision making teams in order to realize complementarities. This is not the case in every large firm. For instance, consulting firms and investment banks with very large staffs often deploy small project teams that operate more or less independently. In such cases the projects that fall under the organization's normal sphere of expertise increase with its size. (We also find that some large companies that usually deploy large teams sometimes try to form small sub-units to undertake 'novel' projects that fall outside their normally circumscribed sphere of activity. Appendix 2 discusses the trade-offs involved.)

Hard rules and hierarchies. Concerns about agents' judgments also explain why large firms may make more extensive use of hard rules than VC, in the absence of winner picking issues. As argued in the previous section, well-codified ('hard') rules help VCs overcome the misgivings of limited partners about the VCs use of tacit knowledge to select investments. Similarly, stockholders in large companies will have concerns about the tacit knowledge that CEOs might use to pool the knowledge of their subordinates. Codified rules for pooling knowledge help mitigate these concerns. When limited partners delegate control to a few VCs, the question of using such rules does not arise. Codified rules also mitigate CEOs' concerns about the tacit knowledge of their subordinates. And since CEOs of large corporations depend on many more subordinates than the number of VCs that limited partners rely on, the use of hard rules is correspondingly more extensive.*

We should also expect to see organizations that rely on many individuals to screen projects to organize these individuals into hierarchies. As Simon (1960) and Radner (1992) have shown, hierarchical or "tree" organizational structures provide efficiencies in the sharing and

*The use of hard rules in large firms has obvious similarities to the bureaucratic model discussed by Weber. The idealized bureaucracy comprises experts who have duties and rights within a "specified sphere of competence" and make decisions "according to *calculable rules*" (Kalberg 1980). Although its procedures can impede "the discharge of business in a manner best adapted to the individuality of each case," Weber argued that in its perfectly developed form, bureaucracy eliminates "love, hatred, and all purely personal, irrational and emotional elements which escape calculation" (Weber 1947).

processing of information across many decision-makers. In other words, hierarchies will appear concurrently with hard rules instead of creating incentives for using hard rules.

The work of business historians and the memoirs and legal testimonies of executives like Sloan and Cary are also more consistent with my explanation of hard rules than the hypothesis that large companies developed hard rules just to, or even primarily to, solve incentive problems. The historical evidence (reviewed in Appendix 2) suggests that as large companies sought to exploit complementarities (or what Chandler refers to as ‘economies of scope’), they faced the problem of effectively pooling the knowledge of many individuals. The top executives of companies like General Motors consciously designed systems and procedures to control these problems and with knowledge of the novelty aversion promoted by their designs. Chandler’s histories, Sloan’s memoirs and Cary’s testimony also do not provide much evidence of concern about winner picking problems (although the steps initially taken to facilitate pooling may have subsequently mitigated such problems as the organizations became more conglomerate-like and may even have encouraged strategies of unrelated diversification).

6. Conclusions

The growth of new forms of organization – first the large public corporation and then VC firms – has apparently led to greater specialization rather than the extinction of prior forms. Large corporations have advantages in realizing complementarities over VCs, but VCs have lower novelty aversion. Both large corporations and VCs have well known advantages in mobilizing capital over individual ‘angel’ investors, but angel investors have a greater tolerance for novelty. Additionally, because even angel investors have some aversion to novelty, self-financing by entrepreneurs remains common.

The varying degrees of novelty aversion in turn derive from principals’ concerns about the biased judgments of rational agents. In self-financed ventures such worries are absent. In angel financed ventures, novelty aversion is driven by an investors’ concern about an entrepreneur. In VC-financed backed firms, limited partners worry about the VC and the VC worries about the entrepreneur. In projects undertaken by publicly traded firms, stockholders worry about the CEO, the CEO worries about a large team of subordinates and the team worries about the entrepreneur (who may also be an employee of the firm).

More generally, the problem of assuaging principals’ concerns about the biased judgments of rational agents seems as ubiquitous as the problem of assuaging concerns about truthfulness, conflicts of interest and irrational errors of coherence. No one can learn everything that everyone else knows or believes. Moreover, especially in technologically progressive

societies, the stock of human knowledge and beliefs itself is in constant flux. Innovators are forever destroying old convictions, for instance about the flatness of the earth and finding new solutions to problems ranging from curing smallpox to the pricing of options. Moreover, new ideas and hypotheses are not accepted or rejected instantaneously – even in the hard sciences as Kuhn (1962) has shown, it usually takes twenty years or more for a paradigm to change. Therefore, on many frontiers in many fields, knowledge is more contentious than ‘common.’ Inevitably, individuals have to form judgments that they know to be at odds with the judgment of some other individual. The dilemma is faced not just by a few innovators but also by many consumers of their innovations. For instance, physicians who aren’t involved in research, have to decide whether to prescribe estrogen replacement therapies knowing that some of their colleagues do and others do not. Inevitably as well, in some situations where the ‘unbiased’ judgments of two individuals are in conflict, third parties will assume that both judgments are biased. Incorporating such concerns into our models and frameworks will considerably improve our understanding of many important joint action and agency problems.

Appendix 1: Tradeoffs between specialization and complementarities in multi-unit organizations.

In section 4 I examined the differences between large and small teams but not between large and small organizations. And there was nothing in my analysis that would preclude an organization from having some large teams and some small teams reporting to a single CEO. My assumptions about the source of errors and the nature of investor skepticism, however, imply that such co-mingling can impair the actual or perceived quality of the CEO. To the extent that CEOs face different tasks in managing large and small sub-units they rely on different kinds of prior knowledge. Co-mingling hinders the development and calibration of this knowledge. Differences between sub-units also make it difficult for top executives to win the confidence of investors -- as previously stipulated, individuals who repeatedly perform the same tasks face less skepticism. Complementarities due to the reduction of transaction costs may however offset the disadvantages of co-mingling units. For instance, an in-house VC unit may help a large firm realize more value from opportunities that are too novel for its existing units, and selling the right to exploit the opportunities involves high transaction costs.

The trade-off between complementarities across sub-units and reductions in the efficiency of top-management decision making is consistent with Gompers and Lerner's (1999) data. They find that in-house VC units are more likely to survive within large firms if they can take advantage of the parent's technologies and relationships than if their investment activities are stand-alone. We may further note that the extent of co-mingling seems relatively modest: in-house venture capital apparently represents a peripheral activity for large U.S. corporations. At their peak in 2000, in-house VCs invested \$17.4 billion, an amount representing approximately 17% of the aggregate VC disbursements in the U.S. In 2001 in-house VCs invested less than \$1 billion. In contrast, Intel alone invested \$11 billion in R&D and other capital expenditures in 2001. Skunk works and other free-wheeling forms of entrepreneurship also appear to have limited staying power in large companies.*

* See for instance: Bartlett and Mohammed's (1995) case study on the retreat of "individualized entrepreneurship" at 3M; former CEO Vagelos's account of his introduction of "rational drug discovery" process at Merck (Nichols 1994); and co-founder Moore's (1996) description of R&D budgeting and planning at Intel.

Appendix 2: Historical evidence about the evolution of organizational structures of large companies.

The historian Alfred Chandler's accounts of the evolution of large public companies suggest a close nexus between project complexity and the development of their control mechanisms. Prior interpretations of Chandler's work by Williamson (1975) and other theorists have emphasized the ability of large corporations to control conflicts of interest. An alternative reading suggests that the problem of pooling the knowledge of many individuals that firms encountered as they undertook increasingly complex projects played an equally important role in the development of their internal control systems.

According to Chandler, firms initially grew by increasing the volume of their outputs using innovative labor saving technologies. These technologies stimulated the development of mechanisms to control conflicts of interest and mistakes. In the prior 'putting out' system of production, workers were paid according to a piece rate (Chandler 1977); assembly line manufacturing required the control of effort through time and motion studies and the employment of foremen and supervisors. The new technologies also increased the problem of pooling information. In the railroads, the failure to pool information effectively sometimes had fatal consequences, as in the collision of two passenger trains in 1841. "The resulting outcry," according to Chandler (1977), "helped bring into being the first modern, carefully defined, internal organization structure used by an American business enterprise."

High volume production encouraged firms to grow through vertical integration. General Motors (GM) for instance acquired some of its 'up-stream' suppliers such as the Fisher Body Company (Chandler and Salsbury 1971). According to Williamson (1975) vertical integration mitigates problems of opportunistic behavior by placing specialized up-stream and downstream units under common ownership. Common ownership however does not by itself eliminate the problem of information pooling. For instance, an upstream unit may build excess capacity because it overestimates the requirements of the downstream unit. By the 1920s, most large U.S. companies adopted 'functional' organizational structures to control such problems (Chandler 1962).

Growth through diversification followed growth through vertical integration. Diversification further increased the problems of information aggregation and placed an "intolerable strain on existing administrative structures." The problems of manufacturing and marketing a number of product lines "made the tasks of departmental headquarters exceedingly difficult to administer...The coordination of product flow through several departments proved even more formidable" (Chandler 1962). These problems led large diversified companies to

establish 'divisions' with dedicated resources. For instance, after a financial crisis in 1920-1, General Motors formed the Cadillac, Buick, Oakland, Olds, and Chevrolet divisions. Between 1921 and 1925 GM created divisional offices, considerably expanded its central office staff, formed inter-departmental committees, and "worked out highly rational and systematic procedures" to coordinate the operating divisions and plan policy for the organization as a whole. By 1925, the divisional and general office staffs "were drawing up comprehensive over-all plans for all operating units" based on "carefully thought-out, long term forecasts" (Chandler 1962).

According to Alfred Sloan, who served as the chief executive from 1923 to 1946, GM also developed a "tradition of selling ideas, rather than simply giving orders." All levels of management had to "make a good case" for their proposals; the manager who wanted to "operate on a hunch" would "find it hard to sell his ideas to others." But the sacrifice of possibly brilliant hunches was compensated for by the "better-than-average results" of policies that could be "strongly defended against well-informed and sympathetic criticism." GM's approach provided a safeguard against "ill-considered decisions by assuring that basic decisions were made only after thorough consideration by all parties concerned" (Sloan 1964).

IBM, according to the historian Olegario, developed its system of collective decision making during the 1950s and 1960s when it faced the "critical problem" of building consensus between engineers and marketers. According to an IBM executive's testimony in the company's 1969-1982 antitrust lawsuit, IBM developed an organization that was "based on checks and balances, which provide a structure to insure the representation... of staff, line, product division, subsidiaries and headquarters viewpoints." The testimony of Frank Cary (who later served as the company's CEO) emphasized the information aggregation role played by the 2500 staff officers in planning new products. According to Cary the staff was responsible for understanding the product and the marketplace and presenting proposals that had "been reviewed, and checked and balanced against Manufacturing, Engineering, Service, [and] both the Domestic and the World Trade Marketing Divisions, before they c[a]me forward to have it further reviewed by the Corporate Staff and the Management Review Committee" (cited in Olegario 1997).

Appendix 3: Extensions

The framework discussed in the main text suggest further hypotheses and questions about the:

Interactions with moral hazard and cognitive biases. Although my analysis assumed away moral hazard, my discussion of its applications did offer some conjectures about the interaction of moral hazard and mistakes. For instance, the discussion in section 5 suggests a life-cycle hypothesis: in start-ups, when no one has much information to conceal, investors' concerns about mistakes often represent a binding financing constraint. As a business matures, entrepreneurs secure more information but may not be able to credibly communicate it to investors. Now the costs of controlling moral hazard may become the binding constraint for outside financing. Similarly, in section 6 I suggested that biases against novelty may increase the expenditures agents incur to control moral hazard – VCs devote more resources to checking references because they favor experienced founders, and experienced founders have longer employment histories available for verification than inexperienced founders.*

My analysis also assumed that investors are only concerned about specific defects in entrepreneurs' prior knowledge rather than overall defects in their reasoning abilities. But in fact, investors also worry about overall defects. And as mentioned, investors who are only concerned about overall defects may not have a bias against novelty.

Such ad-hoc conjectures are of course only a starting point. The development of a formal theory that incorporates moral hazard, mistakes due to defective prior knowledge, and mistakes due to defective reasoning, will provide more systematic predictions.

Design of contracts. Contractual terms can help mitigate the parties' concerns about each other's mistakes and not just their conflicts of interest. One example is the use of 'milestone' or 'benchmark' compensation provisions in VC financing contracts. Milestone provisions typically give the entrepreneur a higher share of the firm's equity upon the attainment of some previously agreed upon goal, such as reaching a revenue target. Although such arrangements are often used, they do not represent a routine feature of VC-entrepreneur contracts; for instance, they were found in less than half the cases studied by Kaplan and Stromberg (2000) – and were more prevalent in early stage financings than in later stage financings.

Incentives do not provide a convincing explanation for why milestone provisions are used in some contracts but not others, and more importantly, why they are used more often in early

* Efforts to control moral hazard and mistakes do not however, always interact. For instance, the control of moral hazard by providing 'carried interests' to VCs may not affect the control of mistakes (Gompers and Lerner 1996).

stage financings. As discussed in section 6, problems of shirking and deliberate misrepresentation should increase in later round financings and lead to a more frequent use of milestones. A subsequent study by Kaplan and Stromberg (2002) also raises questions about an incentive-based explanation. They find “a significantly positive relationship between external risk and benchmark compensation, which is contrary to the theoretical predictions” of traditional agency based models.

The concerns of VCs and entrepreneurs about each other's estimation errors help explain these patterns. My interviews with VCs suggest that VCs try to avoid milestone provisions because they can lead to conflicts and perverse incentives. For instance, if the entrepreneur is on the verge of attaining a revenue milestone, the VC has an incentive to withhold help; or the entrepreneur may over-invest in sales and marketing to reach the milestone even when sacrificing profitability for revenue reduces the total value of the firm. VCs said they reluctantly use milestones to ‘bridge the gap’ between their estimates of the value of the venture and the entrepreneurs’ estimates, rather than to discourage slacking or the pursuit of ‘private benefits.’ Such gaps should be wider in the early stages of a venture.

Duration of control ceded to agents. Hard rules encourage investors to delegate control of their resources for extended periods by protecting investors against the departure or the impairment of the judgment of particular individuals. An organization's reliance on individual judgment instead of hard rules will encourage investors to reserve the right to withdraw funds after appropriate notice or to delegate control for shorter, fixed periods. Control for extended duration in turn gives organizations advantages in sharing a common asset across projects with different start and finish dates.*

Differences between large public firms and VCs conform to this hypothesis. The charters of public companies like Merck anticipate perpetual life and thus encourage managers to undertake projects whose development testing and marketing can span several decades. These companies also seek to exploit ‘synergies’ across projects, for instance, by using common sales and marketing staff for multiple products. Venture capital partnerships, in contrast, usually have a fixed term of about ten years that gives VCs a four to six year exit horizon for investments. VCs therefore tend to use the ease of exit as an investment criterion (MacMillan, Siegal and Subbanarasimha 1985) and include liquidation provisions in their financing contracts with

* Financing practices of the British East India Company illustrate the problems that arise with limited durations of control. In the early years, the Company raised capital for individual voyages; however its “permanent” trading posts provided services to all voyages. The difficulty of valuing these services and conflicts of interests that arose between voyages eventually led the Company to secure “permanent” capital. (Baskin and Miranti 1997)

entrepreneurs that facilitate exit (Kaplan and Stromberg 2000). VC funds also make less of an effort to exploit synergies across projects – each tub in their portfolio stands on its own bottom. Some VC firms (e.g. Kleiner, Perkins) may occasionally try to facilitate mutually beneficial transactions between portfolio companies; but VCs usually do not require one portfolio company to choose an option that would cause it to incur a small loss in order to produce a larger gain for the other company.*

According to Black and Gilson (1998) the liquidation of investments helps capital providers identify VCs with superior skills. My hypothesis suggests a different interpretation: VCs believed to have superior skills can raise funds from investors without instituting ‘hard’ rules, but only for limited periods. Some venture capitalists have tried to adopt structures to extend the duration of their control over investors' funds. For instance, in the 1960s American Research and Development operated as a closed-ended publicly traded fund and other VCs have used ‘evergreen’ partnership structures. These alternatives did not catch on. Apparently the same set of institutional investors who cede perpetual control to the managers of public companies have been unwilling to do so to the general partners of VC firms.

Innovation. According to Rosenberg (1976), Schumpeter’s “model has become the accepted one for all innovative activity.” My propositions raise questions about a key element of this model, namely Schumpeter’s (1911, 1942) attribution of economic growth to radical or discontinuous innovation. Rosenberg’s (1976) work suggests that technological progress is often incremental, although he does not rule out the possibility of large discontinuities. My analysis buttresses Rosenberg’s research: great leaps forward usually do not occur because individual entrepreneurs lack the capital to undertake radical innovations on a large scale, and organizations that have the capital don’t have the necessary tolerance for incomplete information. Significant innovations are more likely the accretive consequence of small, highly novel projects as well as larger, less novel projects. This analysis also suggests that the debate (also inspired by Schumpeter) about whether large or small companies are more innovative is beside the point; in modern economy, different organizations make different kinds of contributions to the innovative process. Research that focuses on the complementarities across organizations and on incremental rather than discontinuous change may therefore have more value than research based on Schumpeter’s model.

*It might be argued that the reluctance to maximize the joint value of the two companies derives from fiduciary restrictions faced by the VCs rather than concerns about exit. Note, however, that the fiduciary restriction reflects a choice made by the VCs to own less than 100 percent of the equity of their portfolio companies. Moreover, LBO partnerships that do own all of the equity of their portfolio companies also avoid co-mingling assets and activities.

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