Boom and Bust in the Venture Capital Industry and the Impact on Innovation

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The past year has seen a dramatic decline in venture capital activity. As Chart 1 shows, investment activity has fallen by more than half in the past few quarters. Fund-raising by venture capital organizations has similarly undergone a sharp fall, and few observers expect a revival anytime soon.

Already voices have been raised, expressing worry about the implications of this decline for technological innovation. If venture capital was really critical for America's rapid economic growth, as many articles in the business press during the past decade have claimed, its sharp decline must surely be grounds for worry. For instance, *Business Week* recently noted, "Most venture capitalists are shelving the expensive change-the-world bets of the past few years. . . . The danger is that cutbacks will go too fast and too deep" (Greene 2001, E14).

This paper seeks to understand the implications of the recent collapse in venture activity for innovation. It argues that the situation may not be as grim as it initially appears. While there are many reasons for believing that, on average, venture capital has a powerful impact on innovation, the impact is far from uniform. In particular, during boom periods, the prevalence of overfunding of particular sectors can lead to a sharp decline in terms of venture funds' effectiveness. While prolonged downturns may eventually lead to good companies going unfunded, many of the dire predictions seem overstated.

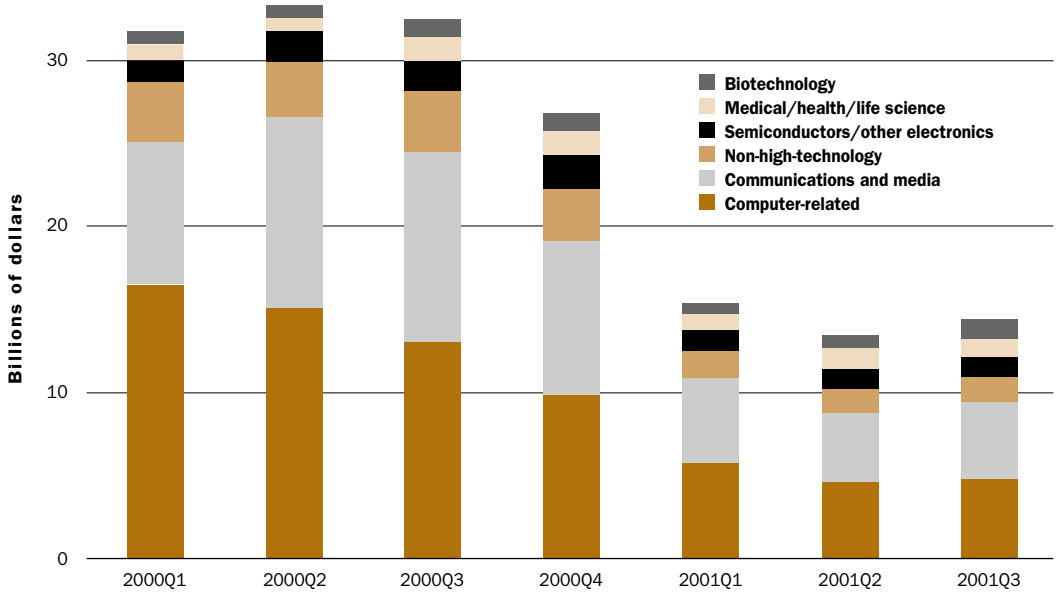
The paper first considers the cyclical nature of the venture industry and explores why shifts in opportunities often do not rapidly translate into increased fund-raising. The discussion also highlights the tendency of the venture capital supply, when it does finally adjust to shifts in demand, to react in an excessively dramatic manner. I explore how the structure of the venture funds themselves and the information lags in the venture investment process may lead to this "overshooting" phenomenon. Similarly, I discuss the determinants of busts like that industry is experiencing today.

Next, the paper considers the implications of these shifts for innovation, reviewing more general evidence that suggests that venture capitalists have a powerful impact on innovation. The discussion then considers both field-based and statistical evidence that the effects of venture investment on innovation are not uniform. I argue that the impact of these funds on innovation during periods of rapid growth, or booms, is attenuated. At the same time, I consider the implications of prolonged troughs, such as the venture industry experienced in the 1970s, and highlight the apparently detrimental consequences of such events.

In the conclusion, I consider some of the implications for public policy. The analysis suggests that, while the rise of venture capital has been an important contributor to technological innovation and economic prosperity, an effective policy agenda going

CHART 1

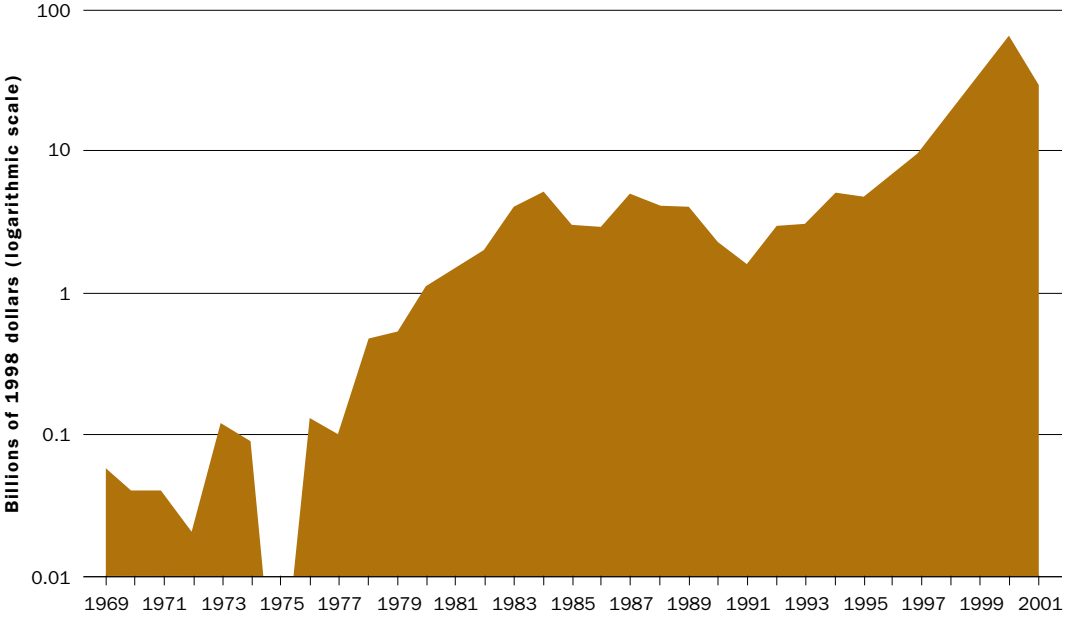
U.S. Venture Capital Investments by Quarter, 2000–2001



Source: Based on an unpublished Venture Economics database

CHART 2

Venture Capital Fund-Raising by Year, 1969–2001

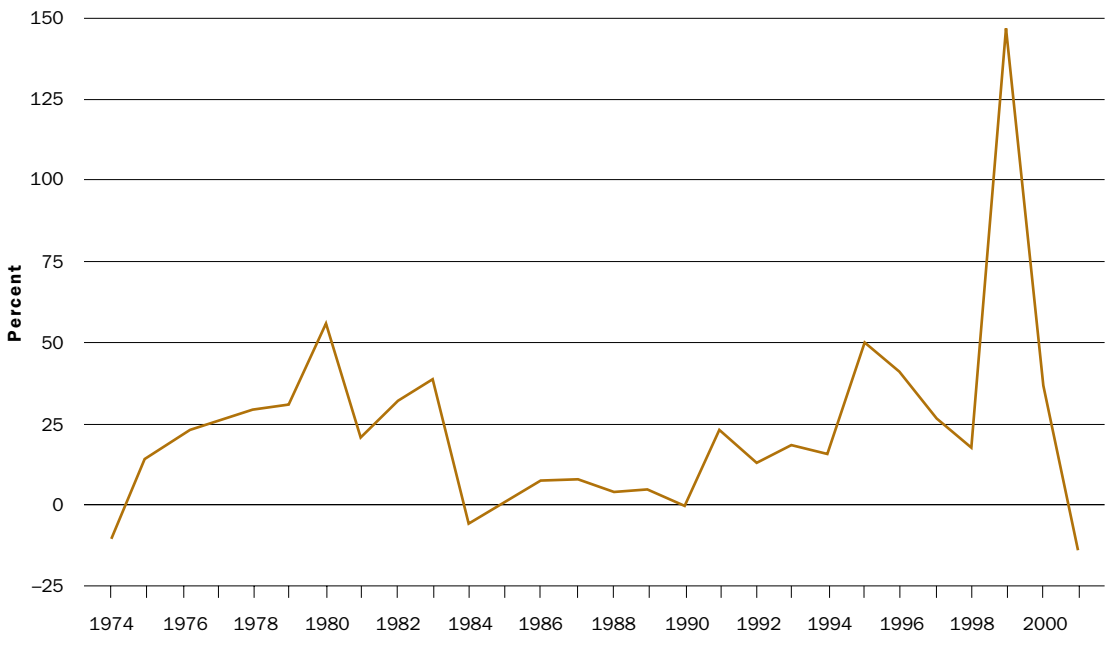


Notes: There were no venture funds raised in 1975; 2001 fund-raising is through November only.

Source: Based on unpublished Asset Alternatives and Venture Economics databases

CHART 3

Returns to Venture Capital Investments, 1974–2001



Note: 2001 returns are for the first six months only.

Source: Based on an unpublished Venture Economics database

forward will not simply seek to spur much venture financing. I highlight the fact that many of the steps policymakers have pursued have had the consequence of throwing gasoline on the fire—that is, they have exacerbated the cyclical nature of venture funding. Instead, the environment for venture capital investment can be substantially improved by government policies (both federal and state) that encourage private investment and address gaps in the private funding process, such as industrial segments that have not historically captured the attention of venture financiers. In short, I argue that policymakers have to view efforts to assist young firms within the context of the changing private-sector environment.

Cyclicality in the Venture Capital Industry

The recent changes in the venture capital market have been far from the first such cycles in the venture market. Charts 2 and 3 depict the changing amount of venture capital funds raised and the returns from these funds. This section will explore what accounts for such extreme variations.

A simple framework. To help understand the dynamics of the venture capital industry, it is helpful to employ a simple framework.[1] The two critical elements for understanding shifts in venture capital fund-raising are straightforward: a demand curve and a supply curve. Just as in markets for commodities like oil and semiconductors, shifts in supply and demand shape the amount of capital raised by venture funds. These shifts also drive the returns that investors earn in these markets.

The supply of venture capital is determined by investors' willingness to provide funds to venture firms. This willingness is, in turn, dependent upon the expected rate of return from these investments relative to the expected return from other investments. Higher expected returns lead to a greater desire of investors to supply venture capital. As the return that investors expect to earn from their venture investments increases—that is, as expected returns rise on a vertical axis—the amount supplied by investors grows (that is, it moves further to the right along a horizontal axis).

The number of entrepreneurial firms seeking venture capital determines the demand for capital. Demand is also likely to vary with the rate of return anticipated by investors. As the minimum rate of

1. The supply and demand framework for analyzing venture capital discussed here was introduced in Poterba (1989) and refined in Gompers and Lerner (1998b).

return sought by investors increases, fewer entrepreneurial firms can meet that threshold. The demand schedule typically slopes downward: higher return expectations lead to fewer financeable firms because fewer entrepreneurial projects can meet the higher hurdle.

Together, supply and demand should determine the level of venture capital in the economy, as illustrated in Chart 4. The level of venture capital should be determined by where the two lines—the supply curve (S) and the demand curve (D)—meet. Put another way, one would expect a quantity (Q) of venture capital to be raised in the economy while the funds earn a return of R on average.

In the venture market the quantity of funds provided may not shift rapidly. The adjustment process is often quite slow and uneven, a fact that can lead to substantial and persistent imbalances.

It is natural to think of supply and demand curves as smooth lines, but this is not always the case. Consider, for instance, the venture capital market before the Department of Labor's clarification of the "prudent man" rule of the Employee Retirement Income Security Act (ERISA) in 1979. Investors' willingness to provide capital before the clarification of ERISA policies seemed to indicate that the supply curve may have been distinctly limited: no matter how high the expected rate of return for venture capital was, the supply would be limited to a set amount. The vertical segment of the supply curve resulted because pension funds, a segment of the U.S. financial market that controlled a substantial fraction of the long-term savings, were simply unable to invest in venture funds. Consequently, the supply of venture capital may have been limited at any expected rate of return.

The impact of shifts. These supply and demand curves are not fixed. For instance, the shift in ERISA policies led to the supply of funds moving outward. Similarly, major technological discoveries, such as the development of genetic engineering, led to an increase in the demand for venture capital.

But the quantity of venture capital raised and the returns it enjoys often do not adjust quickly and smoothly to the changes in supply and demand curves. This fact can be illustrated by comparing the venture capital market to that for snack foods. Companies like Frito-Lay and Nabisco closely monitor the shifting demand for their products, getting daily updates on the data collected in supermarket scanners. They restock the shelves every few days, adjusting the product offerings in response to changing consumer tastes. They can address any imbalances of supply and demand by offering coupons to consumers or making other special offers.

In contrast, in the venture market the quantity of funds provided may not shift rapidly. The adjustment process is often quite slow and uneven, a fact that can lead to substantial and persistent imbalances. When the quantity provided does react, the shift may overshoot the ideal amount and lead to yet further problems.

This dilemma can be illustrated again using my framework. It is important to distinguish here between short- and long-run curves. While in the long run the curve may have a smooth upward slope, the short-run curve may be quite different. The long-run supply curve (SL) may have a smooth upward slope. But the supply in the short run may be essentially fixed if investors cannot or will not adjust their allocations to venture capital funds. Thus, the short-run curve may instead be a vertical line (SS).

This difference is illustrated in Chart 5, which explores the short- and long-run impact of a positive demand shock. The discovery of a new scientific approach, such as genetic engineering, or the diffusion of a new technology, such as the transistor or the Internet, may have a profound effect on the venture capital industry. As large companies struggle to adjust to these new technologies, numerous agile small companies may seek to exploit the opportunity. As a result, for any given level of return demanded by investors, there now may be many more attractive investment candidates.

In the long run, the quantity of venture capital provided will adjust upward, from Q_1 to Q_2. Returns will also increase, from R_1 to R_2. In the months or even years after the shock, however, the amount of venture capital available may be essentially fixed. Instead of the shock leading to more companies being funded, the return to the investors may climb dramatically, up to R_3. Only with time will the rate of return gradually subside as the supply of venture capital adjusts.

There are at least two factors that might lead to such short-run rigidities. These are the structure of the funds themselves and the slowness with which information on performance is reported back to investors. I will explore how each factor serves to dampen the speed with which the venture capital supply adjusts to shifts in demand.

CHART 4

Steady-State Level of Venture Capital

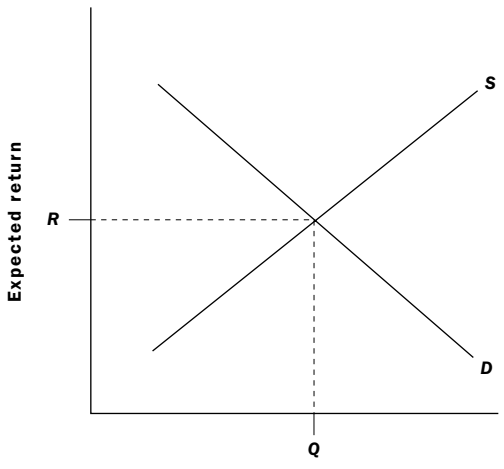
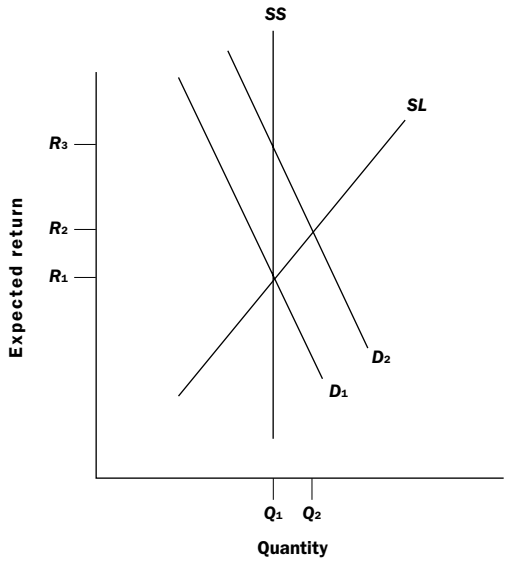


CHART 5

Impact on Quantity of a Demand Shock



The nature of venture funds. When investors wish to increase their allocation to public equities or bonds, this change is easily accomplished. These markets are liquid: shares can be bought and sold easily, and adjustments in the level of holdings can be readily made. The nature of venture capital funds, however, makes these kinds of rapid adjustments much more difficult.

Consider an instance in which a university endowment decides that venture capital is a particularly attractive investment class and decides to increase its allocation to these investments. From the time at which this new target is agreed upon, it is likely to be several years before the policy is fully implemented. Since venture groups raise funds only every two or three years, if the endowment simply wants to increase its commitment to existing funds, it will need to wait until the next fund-raising cycle occurs for these funds. In many cases, the endowment may be unable to invest as much in the new funds as it wishes.

The reluctance of venture groups to accept the endowment's capital stems from the fact that the number of experienced venture capitalists often adjusts more slowly than the swings in capital. Many of the crucial skills of being an effective venture capitalist cannot be taught formally; rather, they need to be developed through a process of apprenticeship. Furthermore, the organizational challenges associated with rapidly increasing the size of a venture partnership are often wrenching ones. Thus, groups such as Kleiner Perkins and Greylock have resisted rapidly increasing their size, even if investor demand is so great that they could easily raise many billions of dollars.

If indeed the endowment decides to undertake a strategy of investing in new funds, potential candidates for the university's funds will need to be exhaustively reviewed. Once the funds are chosen, the investments will not be made immediately. Rather, the capital that the university commits will be drawn down only in stages over a number of years.

The same logic works in reverse. If the endowment or pension officers decide to scale back their commitment to private equity, it is likely to take a number of years to do so. An illustration of this stickiness was seen following the stock market correction of 1987. Many investors, noting the extent of equity market volatility and the poor performance of small high-technology stocks, sought to scale back their commitments to venture capital. Despite these corrections, flows into venture capital funds continued to rise, not reaching their peak until the last quarter of 1989.[2]

Another factor making allocation adjustments more difficult is the self-liquidating nature of venture funds. When venture funds exit investments, they do not reinvest the funds but instead return the capital to their investors. These distributions are typically in the form of either stock in firms that

2. This claim is based on an analysis of an unpublished Venture Economics database.

have recently gone public or cash. The pace of distributions varies with the rate at which venture capitalists are liquidating their holdings.

Thus, during "hot" periods with large numbers of initial public offerings and acquisitions—which are likely to be the times when many investors desire to increase their exposure to venture capital—limited partners receive large outflows from venture funds. Even to maintain the same percentage allocation to venture funds during these peak periods, the institutions and individuals must accelerate their rate of investment. Increasing their exposure is consequently quite difficult. Conversely, during "cold" periods, when investors are likely to wish to reduce their allocation to this asset class, they receive few distributions. Thus, it is often difficult to achieve a desired exposure to venture capital during periods of rapid change in the market.

Once the markets do adjust to the changing demand conditions, they frequently go too far. The supply of venture capital ultimately will rise to meet the increased opportunities, but these shifts often are too large.

The role of information lags. A second factor contributing to the stickiness of the supply of venture capital is the difficulty in discerning what the current status of the venture market is at any given time. While mutual and hedge funds holding public securities are marked to market on a daily basis, the delays between the inception of a venture investment and the discovery of its quality is long indeed.

These information lags can have profound effects. For instance, when the investment environment becomes far more attractive, a number of years may pass before this fact is fully realized. While investments in Internet-related securities in the mid-1990s yielded extremely high returns, it took many years for the majority of institutional investors to realize the size of the opportunity. Similarly, when the investment environment becomes substantially less attractive, as it did during the spring of 2000, investors often continue to plow money into funds (see, for instance, the discussion in Kreutzer 2001).

Some of these information problems stem from the firms themselves. The types of firms that attract venture capital are surrounded by substantial uncertainty and information gaps. But these inevitable difficulties are exacerbated by the manner in which the performance of funds is typically reported. One problem is that venture groups tend to be extremely conservative in reporting how much the firms they invest in are worth, at least until the firms are taken public or acquired. While this conservatism limits the danger that investors will be misled into thinking that the fund is doing better than it actually is, the practice minimizes the information flow about the current state of the market.[3]

This reporting practice, for instance, must lead to caution in evaluating the returns depicted in Chart 3. Because relatively few firms get taken public during cold markets and many do during hot ones, there are many more dramatic write-ups on firms during the years with active public markets. But the actual value-creation process in venture investments is quite different. In many cases, the value of a firm actually increases gradually over time even as it is being held at cost. Thus, the low returns during cold periods understate the progress that is being made, just as the high returns during the peak periods overstate the success during those years. In this way, the signals that venture groups receive are quite limited.

An illustration. The discussion above ignores many of the complex institutional realities that affect the ebbs and flows of venture capital fund-raising. But even such simple tools can be quite helpful in understanding overall movements in venture capital activity, as can be illustrated by considering the recent history of the venture capital industry.

As Chart 2 illustrates, the supply of venture funding began growing rapidly in the mid-1990s. Many practitioners at the time viewed this event glumly, arguing that a boost in venture activity must inevitably lead to a deterioration of returns. Yet the investments during this period enjoyed extraordinary success, as Chart 3 shows. How could these seasoned observers have been so wrong?

The reason is that these years saw a dramatic shift in the opportunities available to venture capital investors. The rapid diffusion of Internet access and the associated development of the World-Wide Web ushered in an extraordinary period in the U.S. economy. The ability to transfer visual and text information in a rapid and interactive manner was a powerful tool, one that would transform both retail activities as well as the internal management of firms.

Such a change led to an increase in the demand for venture capital financing. Thus, for any given level of return that investors demanded, there should have been a considerably greater number of opportunities to fund. Far from declining, the rate of return

that venture investments enjoyed actually rose. Much of this rise reflected the fact that the supply of effective and credible venture organizations adjusted only slowly. As a result, those groups that were active in the market during this period enjoyed extraordinary successes.

Why does the venture market overreact? Another frequently discussed pathology in the venture market is the other side of the same coin. Once the markets do adjust to the changing demand conditions, they frequently go too far. The supply of venture capital ultimately will rise to meet the increased opportunities, but these shifts often are too large. Too much capital may be raised for the outstanding amount of opportunities. Instead of shifting to the new steady-state level, the short-term supply curve may shift to an excessively high level.

The same problem can occur in reverse. A downward shift in demand can trigger a wholesale withdrawal from venture capital financing. Returns rise dramatically as a result. While the supply of venture capital will ultimately adjust, in the interim, promising companies may not be able to attract funding. This section explores two possible explanations for this phenomenon.

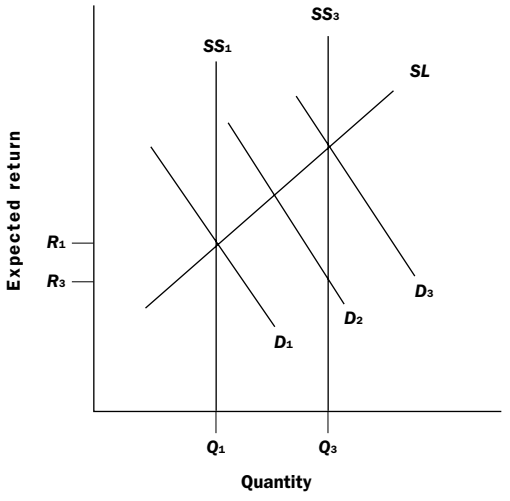
Do public markets provide misleading information? One possibility is that institutional investors and venture capitalists may overestimate the shifts that have occurred. They may believe that there are tremendous new opportunities and consequentially shift the supply of venture capital to meet that apparent demand.

This suggestion is captured in Chart 6. A positive shock to the demand for venture capital occurs, moving the demand curve out from D_1 to D_2. Limited and general partners, however, mistakenly believe that the curve has shifted out to D_3. The short-run supply curve thus shifts from SS_1 to SS_3, leaving excessive investment and disappointing returns in its wake.

Such mistakes may arise because of misleading information from public markets. Examples abound in which venture capitalists have made substantial investments in new sectors, at least partially responding to the impetus provided by the high valuations in that sector. Understanding why public markets overvalue particular sectors is beyond the scope of this piece. Certainly, though, it seems in some cases that investors fail to take into account the impact of competitors: Firms appear to be valued as if they are the sole firm active in a sector, and the impact of competitors on revenues and profit margins is not fully anticipated.

CHART 6

Misleading Public Market Signals



Whatever the causes of these misvaluations, historical illustrations are plentiful. One famous example occurred in the early 1980s, when nineteen disk-drive companies received venture capital financing. (For detailed discussions, see Sahlman and Stevenson 1986 and Lerner 1997.) Two-thirds of these investments came in 1982 and 1983, as the valuation of publicly traded computer hardware firms soared. Many disk-drive companies also went public during this period. While industry growth was rapid at this time (sales increased from $27 million in 1978 to $1.3 billion in 1983), it was questioned at the time whether the scale of investment was rational given any reasonable expectations of industry growth and future economic trends. Indeed, between October 1983 and December 1984, the average public disk-drive firm lost 68 percent of its value. Numerous disk-drive manufacturers that had yet to go public were terminated, and venture capitalists became very reluctant to fund computer hardware firms.

Unreasonable swings in public markets may also lead to over- and underinvestment in venture capital as a whole. Institutions typically try to keep a fixed percentage of their portfolio invested in each asset class. Thus, when public equity values climb, institutions are likely to want to allocate more to venture capital. If the high valuations are subsequently revealed to be without foundations, the

3. The problems with the accounting schemes used by venture capital groups are discussed in Cain (1997), Gompers and Lerner (1998a), and Reyes (1990).

level of venture capital will have once again overshot its target.

Do venture capitalists underestimate the cost of change? A second explanation for the overshooting phenomenon is venture capitalists' failure to consider the costly adjustments associated with the growth of their own investment activity. The very act of increasing the pool of venture capital under management may cause distractions and introduce organizational tensions. Even if demand has expanded, the number of opportunities that a venture group—or the industry as a whole—can address may at first be limited.

Why might these adjustment costs come about? One possibility is that growth frequently leads to changes in the way venture groups invest their capital, thus having a deleterious effect on returns. A second possibility is that growth introduces strains on the venture organization itself.

During periods of rapid growth, venture capital groups may correctly observe that there are many more opportunities to fund. Rapidly expanding to address these opportunities may be counterproductive, however, and lead to disappointing returns.

First, consider the types of pressures that rapid growth imposes on the venture investment process. Rather than making more investments, rapidly growing venture organizations frequently attempt to increase their average investment size. In this way, the same number of partners can manage a larger amount of capital without an increase in the number of firms that each needs to scrutinize. This shift to larger investments has frequently entailed making larger capital commitments to firms up front. Such a move has the potential cost of reducing the venture capitalist's ability to control the firm using staged capital commitments.

Similarly, venture firms syndicate less with their peers during these times. By not syndicating, venture groups can put more money to work. As the sole investor, the venture group can allow each of its partners to manage more capital while keeping the number of companies that it is responsible for down to a manageable level. But syndication can have a number of advantages, such as helping reduce the danger of costly investment mistakes.

Another set of explanatory factors relates to organizational pressures. Limited and general partners may underestimate the consequences of expanding the scale (and the scope) of the fund. An essential characteristic of venture capital organizations has been the speed with which decisions can be made and the parallel incentives that motivate the parties. An expansion of the fund can lead to a fragmentation of the bonds that tie the partnership into a cohesive whole.

One dramatic illustration of these challenges is the experience of Schroder Ventures (see Bingham, Ferguson, and Lerner 1996). Schroders' private equity effort began in 1985 with funds focused on British venture capital and buyout investments. Over time, however, it added funds focusing on other markets, such as France and Germany, and particular technologies, such as the life sciences. The venture capitalists—and the institutional investors backing them—realized that there were substantial opportunities in these other markets.

But as the venture organization grew, substantial management challenges emerged. In particular, it became increasingly difficult to monitor the investment activities of each of the groups, a real concern since the parent organization served as the general partner of each of the funds (and thus was ultimately liable for any losses). Each of the groups saw itself as an autonomous entity and even, in some cases, resisted cooperating (and sharing the capital gains) with the others. While the organization eventually completed a restructuring that allowed it to raise a single fund for all of Europe, the process of change was a slow and painful one.

These tensions are by no means confined to international venture capital organizations. Very similar tensions have appeared in rapidly growing U.S. groups between general partners specializing in life science and information technology and those located in different regions. In some instances, one of these groups has become convinced that the other is getting a disproportionate share of rewards in light of their relative investment performances. In others, it has become difficult to coordinate and oversee activities.

In some cases, these tensions have led to groups splitting apart. For instance, in August 1999, Institutional Venture Partners and Brentwood Venture Capital—funds that had each invested about $1 billion over several decades—announced their intention to restructure (Barry and Toll 1999). The information technology and life sciences venture capitalists from the two firms indicated that they would join with each other to form two new venture capital firms. Pallidium Venture Capital would exclusively pursue health care transactions while Redpoint

Ventures would focus on Internet and broadband infrastructure investments. Press accounts suggested the decision was largely driven by the dissatisfaction of some of the information technology partners at the firms, who felt that their stellar performances had not been appropriately recognized.

In other cases, a key partner—often dissatisfied with his role or compensation—has departed a venture group, entailing a real disruption to the organization. For instance, Ernest Jacquet left to form Parthenon Ventures shortly after Summit Partners closed on a $1 billion buyout fund ("Summit's Jacquet…" 1999). While it is relatively rare for investors to ask funds to return their capital—though, for instance, Foster Capital Management returned $200 million after several junior partners departed in 1998, and several funds have recently cut their size under pressure from general partners—these defections can nonetheless affect the workings and continuity of these groups ("Foster Management…" 1998).

In short, rapid growth puts severe pressures on venture capital organizations. Even when the problems do not result in an extreme outcome such as a group dissolving, the demands on the partners' time in resolving these problems have often been substantial. Thus, during periods of rapid growth, venture capital groups may correctly observe that there are many more opportunities to fund. Rapidly expanding to address these opportunities may be counterproductive, however, and lead to disappointing returns.

The Consequences for Innovation

While understanding the causes of cyclicality in the venture industry may be interesting, policymakers are much more likely to be interested in its consequences. In particular, to what extent do these changes affect the innovativeness of the U.S. economy?

This section explores this question. I begin by considering the evidence regarding the overall impact of venture capital on innovation and then turn to exploring the impact of the boom-and-bust pattern on these shifts. I highlight that while the overall relationship between venture capital and innovation is positive, the relationships across the cycles of venture activity may be quite different.

The basic rationale. A lengthy theoretical literature has been developed in recent years as financial economists have sought to understand the mechanisms employed by venture capitalists. These works suggest that these financial intermediaries are particularly well suited for nurturing innovative new firms.

Before considering the mechanisms employed by venture capitalists, it is worth highlighting that a lengthy literature has discussed the financing of young firms. Young firms, particularly those in high-technology industries, are often characterized by considerable uncertainty and information gaps that make the selection of appropriate investments difficult and permit opportunistic behavior by entrepreneurs after financing is received. This literature has also highlighted the role of financial intermediaries in alleviating moral hazard and information asymmetries.

To briefly review the types of conflicts that can emerge in these settings, Jensen and Meckling (1976) demonstrate that agency conflicts between managers and investors can affect the willingness of both debt and equity holders to provide capital. If the firm raises equity from outside investors, the manager has an incentive to engage in wasteful expenditures (for example, lavish offices) because he may benefit disproportionately from these but does not bear their entire cost. Similarly, if the firm raises debt, the manager may increase risk to undesirable levels. Because providers of capital recognize these problems, outside investors demand a higher rate of return than would be the case if the funds were internally generated.

By intensively scrutinizing firms before providing capital and then monitoring them afterwards, venture capital organizations can alleviate some of the information gaps and reduce capital constraints.

Even if the manager is motivated to maximize shareholder value, informational asymmetries may make raising external capital more expensive or even preclude it entirely. For instance, Myers and Majluf (1984) demonstrate that equity offerings of firms may be associated with a "lemons" problem (first identified by Akerlof 1970). If the manager is better informed about the investment opportunities of the firm and acts in the interest of current shareholders, then managers only issue new shares when the company's stock is overvalued. Indeed, numerous studies have documented that stock prices decline upon the announcement of equity issues largely because of the negative signal that it sends to the market.

These information problems have also been shown to exist in debt markets. Stiglitz and Weiss (1981) show that if banks find it difficult to discriminate among companies, raising interest rates can have perverse selection effects. In particular, the high interest rates discourage all but the highest-risk borrowers, so the quality of the loan pool declines markedly. To address this problem, banks may restrict the amount of lending rather than increase interest rates.

These problems in the debt and equity markets are a consequence of the information gaps between the entrepreneurs and investors. If the information asymmetries could be eliminated, financing constraints would disappear. Financial economists argue that specialized financial intermediaries, such as venture capital organizations, can address these problems. By intensively scrutinizing firms before providing capital and then monitoring them afterward, venture capital organizations can alleviate some of the information gaps and reduce capital constraints.

In some cases, surges in venture capital activity have been followed by pronounced and persistent downturns. Just as one can see overshooting by investors, so can one see prolonged undershooting.

To address these information problems, venture investors employ a variety of mechanisms. First, business plans are intensively scrutinized: of those firms that submit business plans to venture organizations, historically only 1 percent have been funded. The decision to invest is frequently made conditional on the identification of a syndication partner who agrees that this is an attractive investment. Once the decision to invest is made, venture capitalists frequently disburse funds in stages. Managers of these venture-backed firms are forced to return repeatedly to their financiers for additional capital in order to ensure that the money is not squandered on unprofitable projects. In addition, venture capitalists intensively monitor managers. These investors demand preferred stock with numerous restrictive covenants and representation on the board of directors. Thus, it is not surprising that venture capital has emerged as the dominant form of equity financing in the United States for privately held high-technology businesses.[4]

The supporting evidence. One might think that it would not be difficult to address the question of the impact of venture capital on innovation. For instance, one could look at regressions across industries and time to determine whether, controlling for research and development (R&D) spending, venture capital funding has an impact on various measures of innovation. But even a simple model of the relationship between venture capital, R&D, and innovation suggests that this approach is likely to give misleading estimates.

Both venture funding and innovation could be positively related to a third unobserved factor, the arrival of technological opportunities. Thus, there could be more innovation at times when there is more venture capital not because the venture capital caused the innovation but rather because the venture capitalists reacted to some fundamental technological shock that was sure to lead to more innovation. To date, only two papers have attempted to address these challenging issues.

The first of these studies, Hellmann and Puri (2000), examines a sample of 170 recently formed firms in Silicon Valley, including both venture-backed and nonventure firms. Using questionnaire responses, they find empirical evidence that venture capital financing is related to product market strategies and outcomes of start-ups. They find that firms that are pursuing what they term an innovator strategy (a classification based on the content analysis of survey responses) are significantly more likely and faster to obtain venture capital. The presence of a venture capitalist is also associated with a significant reduction in the time taken to bring a product to market, especially for innovators. Furthermore, firms are more likely to list obtaining venture capital as a significant milestone in the lifecycle of the company as compared to other financing events.

The results suggest significant interrelations between (1) investor type and product market dimensions and (2) the role of venture capital in encouraging innovative companies. Given the small size of the sample and the limited data, Hellmann and Puri can only modestly address concerns about causality. Unfortunately, the possibility remains that more innovative firms select venture capital for financing rather than venture capital causing firms to be more innovative.

Kortum and Lerner (2000), by way of contrast, examine the patterns that can be discerned on an aggregate industry level rather than on the firm level. They address concerns about causality in two ways. First, they exploit the major discontinuity in the recent history of the venture capital industry.

As discussed above, in the late 1970s the U.S. Department of Labor clarified ERISA, a policy shift that freed pensions to invest in venture capital. This shift led to a sharp increase in the funds committed to venture capital. This type of exogenous change should identify the role of venture capital because it is unlikely to be related to the arrival of entrepreneurial opportunities. Kortum and Lerner exploit this shift in instrumental variable regressions. Second, they use R&D expenditures to control for the arrival of technological opportunities that are anticipated by economic actors at the time but that are unobserved by econometricians. In the framework of a simple model, they show that the causality problem disappears if they estimate the impact of venture capital on the patent-R&D ratio rather than on patenting itself.

Even after these causality concerns are addressed, the results suggest that venture funding does have a strong positive impact on innovation. The estimated coefficients vary according to the techniques employed, but on average a dollar of venture capital appears to be three to four times more potent in stimulating patenting than a dollar of traditional corporate R&D. The estimates therefore suggest that venture capital, even though it averaged less than 3 percent of corporate R&D from 1983 to 1992, is responsible for a much greater share—perhaps 10 percent—of U.S. industrial innovations in this decade.

The impact of market cycles. The evidence that venture capital has a powerful impact on innovation might lead one to be especially worried about market downturns. A dramatic fall in venture capital financing, it is natural to conclude, would lead to a sharp decline in innovation.

But this reasoning, while initially plausible, is somewhat misleading because the impact of venture capital on innovation does not appear to be uniform. Rather, during periods when the intensity of investment is greatest, the impact of venture financing appears to decline. The uneven impact of venture on innovation can be illustrated with both a case study and empirical evidence.

Field-based evidence. I have already discussed how in many instances the levels of funding during peak periods appear to overshoot the desired levels. Whether this overshooting is caused by the presence of misleading public market signals or overoptimism on the part of venture capitalists, funds appear to be deployed much less effectively during these boom periods.

In particular, all too often these periods find venture capitalists funding firms that are too similar to one another.[5] The consequences of this excessive duplication are frequently the same: highly duplicative research agendas, intense bidding wars for scientific and technical talent culminating with frequent defections from firm to firm, costly litigation concerning intellectual property rights and misappropriation of ideas across firms, and the sudden termination of funding for many of these concerns.

One example was the peak period of biotechnology investing in the early 1990s. While the potential of biotechnology to address human disease was doubtless substantial, the extent and nature of financing seemed to many observers at the time hard to justify. In some cases, dozens of firms pursuing similar approaches to the same disease target were funded. Moreover, the valuations of these firms often were exorbitant: for instance, between May and December 1992, the average valuation of the privately held biotechnology firms financed by venture capitalists was $70 million. These doubts were validated when biotechnology valuations fell precipitously in early 1993: by December 1993, only 42 of 262 publicly traded biotechnology firms had a valuation over $70 million.[6]

Most of the biotechnology firms financed during this period ultimately yielded very disappointing returns for their venture financiers and modest gains for society as a whole. In many cases, the firms were liquidated when further financing could not be arranged. In others, the firms shifted their efforts into other, less competitive areas, largely abandoning the initial research efforts. In yet others, the companies remained mired with their peers for years in costly patent litigation.

The boom of 1998–2000 provides many additional illustrations. Funding during these years was concentrated in two areas: Internet and telecommunication

4. While evidence regarding the financing of these firms is imprecise, Freear and Wetzel's (1990) survey suggests that venture capital accounts for about two-thirds of the external equity financing raised by privately held technology-intensive businesses from private-sector sources.
5. These results are also consistent with theoretical works in "herding" by investment managers. These models suggest that when, for instance, investment managers are assessed on the basis of their performance relative to their peers (rather than against some absolute benchmark), they may end up making investments similar to each other. For a review of these works, see Devenow and Welch (1996).
6. These figures are based on an analysis of an unpublished Venture Economics database.

TABLE

Implied Impact of Venture Capital on Innovation

	Coefficient or *p*-value
Implied potency of venture financing, normal industry periods	13.57
Implied potency of venture financing, overheated industry periods	11.53
p-value, test of difference between normal and overheated industry periods	0.000

Note: The first row presents the implied impact of venture financing on innovation for all manufacturing industries and years between 1965 and 1992 except those in which the levels of venture inflows are in the top 1 percent. The second row presents the implied coefficient for the industries and years in which inflows are in the top 1 percent. The final row presents the *p*-value from a test that the two coefficients are identical.

Source: Based on the linear patent production function estimated by Kortum and Lerner (2000)

investments, which, for instance, accounted for 39 percent and 17 percent, respectively, of all venture disbursements in 1999. Once again, considerable sums were devoted to supporting highly similar firms—for example, the nine dueling Internet pet food suppliers—or else efforts that seemed fundamentally uneconomical and doomed to failure, such as companies that undertook the extremely capital-intensive process of building a second cable network in residential communities. Meanwhile, many apparently promising areas—for example, advanced materials, energy technologies, and micro manufacturing—languished unfunded as venture capitalists raced to focus on the most visible and popular investment areas. It is difficult to believe that the impact of a dollar of venture financing was as powerful in spurring innovation during these periods as in others.

Statistical evidence. These suggestive accounts are borne out in a statistical analysis. Using the framework of Kortum and Lerner (2000), I show that the impact of venture capital on innovation was less pronounced during boom periods.

In this analysis, I analyze annual data for twenty manufacturing industries between 1965 and 1992. The dependent variable is U.S. patents issued to U.S. inventors by industry and date of application. My main explanatory variables are measures of venture funding collected by Venture Economics and industrial R&D expenditures collected by the U.S. National Science Foundation (NSF).

To be sure, these measures are limited in their effectiveness. For instance, companies do not patent all commercially significant discoveries (though in the original paper, I show that the patterns appear to hold when I use other measures of innovation). Similarly, I am required to aggregate venture funding and patents into a twenty-industry scheme that is used by the NSF to measure R&D spending. Finally, my analysis must exclude the greatest boom period of all, the 1998–2000 surge (patent applications can be observed only with a considerable lag).

The table presents my estimate of the influence of venture capital funding on patent applications, controlling for R&D spending, industry effects, and the year of the observation. Any number greater than one implies that venture capital is more powerful than traditional corporate R&D in spurring innovation. (This is a specification similar to regression 3.2 in that paper, with the addition of an added measure for the "hottest" periods.) I then show the implied coefficient when I estimate the impact of venture capital on innovation separately for those periods that had the great venture capital investments (defined here as the top 1 percent of industry-year observations). As the table reports, the impact of venture capital on innovation is some 15 percent lower during the boom periods, a difference that is strongly statistically significant.

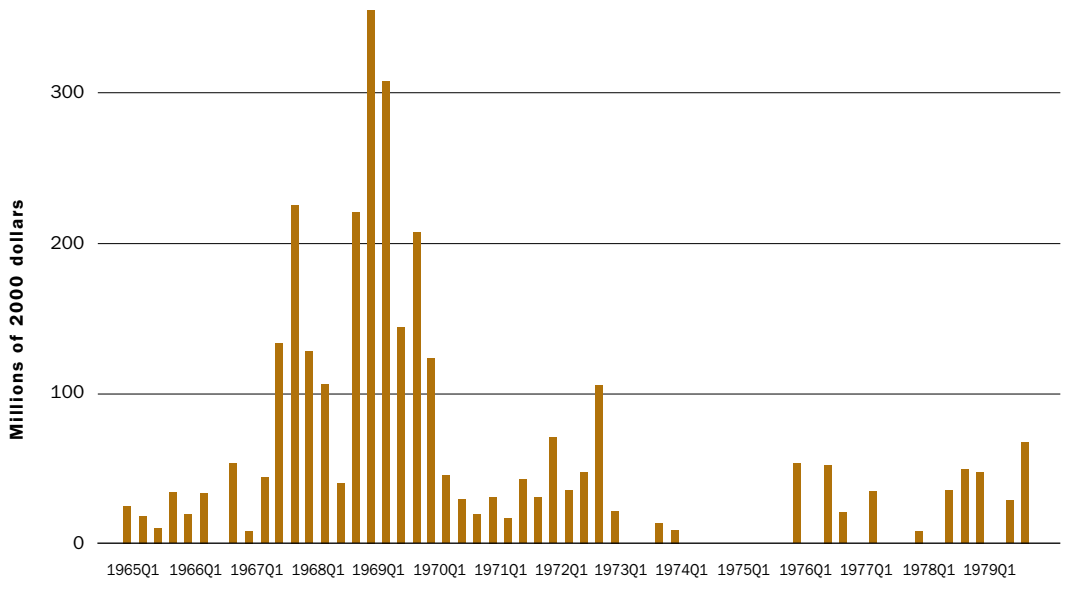
As discussed in Kortum and Lerner (2000), the magnitude of the impact of venture capital on innovation diminishes—but remains positive and significant—when I control for reverse causality: the fact that technological breakthroughs are likely to stimulate venture capital investments. When I repeat the analysis reported here using a number of these complex specifications, the magnitude of the difference between normal and boom periods remains similar, and the percentage difference widens. This statistical result corroborates the field study evidence suggesting that venture capital's impact on innovation is less pronounced during booms.

A cautionary note. These patterns may lead us to worry less about the short-run fluctuations in venture financing. While the impact on entrepreneurial activity is likely to be dramatic, the effects on innovation should be more modest.

This conclusion, however, must be tempered by the awareness of history: In some cases, surges in venture capital activity have been followed by pronounced and persistent downturns. As alluded to above, just as one can see overshooting by investors, so can one see prolonged undershooting.

CHART 7

Initial Public Offerings and Seasoned Equity Offerings by Computer and Computer-Related Firms, by Quarter, 1965–79



Source: Compiled by the author from information from *Investment Dealers' Digest*, the Securities Data Company database, and other sources

One sobering example was the 1970s. The late 1960s had seen record fund-raising, both by independent venture groups and small business investment companies (SBICs), federally subsidized pools of risk capital. Many of the investments by the less-established venture groups failed in the subsequent recession, particularly those of the SBICs. (The selection process for these licenses appeared to emphasize political connections over investment acumen). The poor returns generated a powerful reaction, leading both public and private market investors to be unwilling to contribute new capital.

Chart 7 depicts one consequence of the period of this reaction. The graph depicts the volume of initial and follow-on offerings in the sector that saw the greatest concentration of venture investments during this period: computer and computer-related firms. The amount of capital raised by these firms fell from $1.2 billion (in today's dollars) in 1968–69 to just $201 million in the entire period from 1973 to mid-1978, with absolutely no financing being raised in many quarters. To be sure, many of the firms that raised capital during the boom years and then could not get refinanced had business plans that were poorly conceptualized or were engaged in doomed battles with entrenched incumbents such as IBM. But many other firms seeking to commercialize many of the personal computing and networking technologies that would prove to have such a revolutionary impact in the 1980s and 1990s also struggled to raise the financing necessary to commercialize their ideas.

At the same time, it is important to note that while venture capital fund-raising and investment has cooled down considerably from the white-hot days of 2000, the level of activity is still extremely high from a historical perspective. In fact, if one were to remove the 1999–2000 bubble period from Chart 2, the venture industry has shown robust growth over the past decade. As a result, the rationale for government intervention to provide funding today seems slim, as I discuss in more detail below.

Conclusions

Government officials and policy advisers are naturally concerned about spurring innovation. Encouraging venture capital financing is an increasingly popular way to accomplish these ends; numerous efforts to spur such intermediaries have been launched in many nations in Asia, Europe, and the Americas. But far too often these efforts have ignored the relationships discussed above.

As I have highlighted, venture capital is an intensely cyclical industry, and the impact of venture capital on innovation is likely to differ with this cycle. Yet government programs have frequently

been concentrated during the time periods when venture capital funds have been most active and often have targeted the very same sectors that are being aggressively funded by venture investors.

This type of behavior reflects the manner in which such policy initiatives are frequently evaluated and rewarded. Far too often, the appearance of a successful program is far more important than actual success in spurring innovation. For instance, many "public venture capital" programs, such as the Small Business Innovation Research (SBIR) initiative, prepare glossy brochures full of "success stories" about particular firms. The prospect of such recognition may lead a program manager to decide to fund a firm in a hot industry whose prospects of success may be brighter, even if the sector is already well funded by venture investors (and the impact of additional funding on innovation is quite modest). To cite one example, the Advanced Technology Program launched major efforts to fund genomics and Internet tools companies during periods when venture funding was flooding into these sectors (Gompers and Lerner 1999).

The greatest assistance to venture capital may be provided by government programs that seek to enhance the demand for these funds rather than the supply of capital.

In contrast, the Central Intelligence Agency's In-Q-Tel fund appears to have done a much better job of seeking to address gaps in traditional venture financing (Business Executives 2001). The SBIR program provides another contrasting example. Decisions about whether to finance firms are made not by centralized bodies but rather devolved in many agencies to program managers who are seeking to address very specific technical needs (for example, an Air Force research administrator who is seeking to encourage the development of new composites). As a result, many offbeat technologies that are not of interest to traditional venture investors have been funded through this program.

A far more successful approach would be to address the gaps in the venture financing process. As noted above, venture investments tend to be focused into a few areas of technology that are perceived to have great potential. Increases in venture fund-raising—which are driven by factors such as shifts in capital gains tax rates—appear more likely to lead to more intense competition for transactions within an existing set of technologies than to greater diversity in the types of companies funded. Policymakers may wish to respond to these industries conditions by (1) focusing on technologies that are not currently popular among venture investors and (2) providing follow-on capital to firms already funded by venture capitalists during periods when venture inflows are falling.

More generally, the greatest assistance to venture capital may be provided by government programs that seek to enhance the demand for these funds rather than the supply of capital. Examples would include efforts to facilitate the commercialization of early-stage technology, such as the Bayh-Dole Act of 1980 and the Federal Technology Transfer Act of 1986, both of which eased entrepreneurs' ability to access early-stage research. Similarly, efforts to make entrepreneurship more attractive through tax policy (for example, by lowering tax rates on capital gains relative to those on ordinary income) may have a substantial impact on the amount of venture capital provided and the returns that these investments may yield. These less direct measures may have the greatest success in ensuring that the venture industry will survive the recent upheavals.

In short, while most government programs aimed at spurring venture capital and entrepreneurial innovation likely have experienced a positive social rate of return, the most effective programs and policies seem to be those that lay the foundations for effective private investment. My analysis suggests that the market for venture capital may be subject to substantial imperfections and that these imperfections may substantially lower the total social gain achieved by venture finance. Given the extraordinary rate of growth (and now retrenchment) experienced by venture capital over the past decade, the most effective policies are likely those that focus on increasing the efficiency of private markets over the long term rather than providing a short-term funding boost during the current period of transition.

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