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INNOVATION, ENTREPRENEURSHIP AND FINANCIAL MARKET CYCLES

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By Josh Lerner
Harvard University

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INNOVATION, ENTREPRENEURSHIP AND FINANCIAL MARKET CYCLES

Josh Lerner[1]
Harvard University

Abstract

While hard data is difficult to find, the financial crisis appears to have had a substantial negative effect on investors' willingness to finance innovative entrepreneurship. This dearth of capital is particularly worrisome in light of the widely recognised need for innovative ventures—the so-called "green shoots"—to reignite economic growth after the world-wide recession. A growing body of evidence suggests a strong relationship between entrepreneurship, innovation, and economic growth.

This document first reviews the evidence concerning the relationship between innovation and entrepreneurship. It then turns to understanding the consequences of market cycles for these activities. We look at the way that financial considerations impact the innovation investment decision, and innovation in entrepreneurial ventures specifically.

I then turn to the implications of the current economic crisis. and highlight four crucial observations:

- The current global crisis is having a dramatic effect on the financing of innovation, whether through venture capital, initial public offerings, or corporate venturing.
- This is not the first such crisis in entrepreneurial finance.
- These patterns reflect the fact that financial constraints appear to limit high potential entrepreneurs.
- These funding cycles are serious because of the importance of high potential ventures for innovation.

I end by discussing the implications for the growing number of government programmes that seek to encourage financing for entrepreneurs and venture capital. Far too often, these efforts have ignored the relationships discussed above.

1 Katherine Han and Alexandra Lowery provided excellent research support. I thank Bill Kerr and Ramana Nanda for helpful conversations about financing constraints and entrepreneurship, as well as Chiara Criscuolo, Dominique Guellec, and Karen Wilson for useful comments on this document. Portions of this essay are based on Azoulay and Lerner (2010), Gompers and Lerner (2001), and Hall and Lerner (2010); I thank my co-authors for permission to use excerpts from these jointly authored pieces. I thank the OECD and Harvard Business School's Division of Research for financial support. All errors and omissions are my own.

INNOVATION, ENTREPRENEURIAT ET CYCLES DES MARCHES DE CAPITAUX

Josh Lerner[2]
Harvard University

Résumé

Il est difficile de trouver des données objectives sur la question, mais la crise financière semble avoir eu un effet négatif sensible sur la disposition des investisseurs à financer les entreprises innovantes. Cette pénurie de capital est particulièrement inquiétante à la lumière du besoin largement admis d'entreprises innovantes – les fameuses « jeunes pousses » – pour relancer la croissance économique après la récession mondiale. De plus en plus d'éléments laissent à penser qu'il existe un lien fort entre entrepreneuriat, innovation et croissance économique.

Ce document s'ouvre sur un examen des informations disponibles concernant la relation entre innovation et entrepreneuriat. Je m'efforce ensuite de cerner les conséquences des cycles des marchés sur ces activités. J'examine la façon dont les considérations financières se répercutent sur les décisions d'investissement en matière d'innovation, et plus précisément s'agissant de l'innovation réalisée dans les jeunes entreprises.

Je me penche ensuite sur les conséquences de la crise économique actuelle, en mettant en exergue quatre observations cruciales :

- La crise mondiale actuelle a un effet spectaculaire sur le financement de l'innovation, qu'il repose sur le capital-risque classique, les introductions en bourse ou les investissements en capital-risque des grandes entreprises.
- Ce n'est pas la première crise que traverse le financement des jeunes entreprises.
- Ces évolutions montrent que des entrepreneurs à fort potentiel semblent entravés par des contraintes financières.
- Ces cycles de financement ont une incidence non négligeable, compte tenu de l'importance que revêtent les jeunes entreprises à fort potentiel pour l'innovation.

Enfin, j'examine les conséquences qui en découlent pour le nombre croissant de programmes publics qui visent à encourager le financement des entrepreneurs et le capital-risque. Trop souvent, ces programmes ne tiennent pas compte des relations susmentionnées.

[2] Katherine Han et Alexandra Lowery m'ont apporté un excellent soutien en matière de recherches. Je remercie Bill Kerr et Ramana Nanda pour les conversations riches d'enseignements qu'ils m'ont accordées sur les difficultés de financement et l'entrepreneuriat, ainsi que Chiara Criscuolo, Dominique Guellec et Karen Wilson pour leurs précieux commentaires sur ce document. Des parties de cet essai sont fondées sur Azoulay et Lerner (2010), Gompers et Lerner (2001) ainsi que Hall et Lerner (2010) ; je remercie mes co-auteurs de m'avoir autorisé à utiliser des extraits de leurs études. Je remercie l'OCDE et la Division des recherches de la Harvard Business School pour leur soutien financier. Toutes les erreurs et omissions éventuelles restent de ma responsabilité.

TABLE OF CONTENTS

1. Introduction: The financial crisis and innovation

1.a. Short summary of the crisis

The current economic crisis has been remarkable for its intensity and breadth. The National Bureau of Economic Research (NBER, 2008) declared the US economy to have entered a recession as of December 2007; however, economic conditions had already been in a downward spiral in much of the developed world [for two overviews, see Foster and Magdoff (2009) and Hilsenrath and Soloman (2009)]

The recession's inception was inextricably linked to the US housing bubble. When the Federal Reserve lowered interest rates in 2001 to stimulate the economy in the aftermath of the technology bubble and 9/11, low rates opened the door for easy credit in the housing market. From 2002 to 2004, as interest rates remained low, sub-prime lending became commonplace. Consumers took advantage of favourable credit conditions to get mortgages and financial institutions marketed new lending products and financial instruments. Borrowers could, for example, be approved for a home loan with almost no down payment, while lenders could relinquish themselves of vested interest in the quality of loans when they passed them on to institutional investors. The demand for and value of homes climbed into 2006, but by mid-2007 a credit crisis loomed.

The consequences of haphazard lending practices and a poorly regulated system quickly caught up with financial markets worldwide. By the autumn of 2008, when investment banks like Bear Stearns and Lehman Brothers caved under the pressure of devalued mortgage-backed securities, a credit crunch was imminent. Increasing numbers of homeowners defaulted on loans or were forced into foreclosure when, for instance, they could not make increasing mortgage payments. Lenders found themselves with mortgage-backed securities worth next to nothing. The bursting of the housing bubble and the troubles of the large institutions who held them sparked a liquidity crisis where lending virtually came to a halt, the credit system seizing altogether. On 18 September 2009, the US. government stepped in with a USD700 billion bail-out plan in hopes of saving a financial system on the brink of a total meltdown by ending the cycle of "toxic" assets and injecting enough capital into banks to jump-start the credit market. The government took over Fannie Mae and Freddie Mac and bailed-out AIG during September and effectively took on over USD 5 trillion worth of debt obligations when combined with other bank-debt guarantees. Similar bail-outs occurred in other nations with troubled banks, most notably Switzerland and the United Kingdom.

During the past year, government intervention to stimulate the economy has become routine, almost expected, but the economies of many developed nations remain fragile. Massive debt looms, the stock market remains volatile, and concerns over unemployment, the danger of inflation, and flailing basic industries continue to sap consumer confidence. While there are signs of recovery in certain markets, key sectors such as housing remain dependent on government support.

1.b. Anecdotal accounts of impact on entrepreneurship and innovation

While hard data is difficult to find, the financial crisis appears to have had a substantial negative effect on investors' willingness to finance innovative entrepreneurship. This dearth of capital is particularly worrisome in light of the widely recognised need for innovative ventures — the so-called "green shoots" — to reignite economic growth after the worldwide recession.

By way of introduction, the finance landscape for high-potential entrepreneurs can be seen as a spectrum, where more advanced companies get progressively larger amounts of funds from differing sources:

- At the earliest stages, individual “angels,” including friends, family members, and successful entrepreneurs, provide the bulk of the funding.
- Somewhat more developed entities can attract venture funding, first for seed and early-stage investments, then for larger later-stage and mezzanine investments.
- In conjunction with (and as a substitute for) this later-stage financing, new ventures may be able to access funding from corporations (either through alliances or strategic investments) and banks.
- At the high end, successful entrepreneurs can access the public markets, either through initial or follow-on public offerings. Alternatively, large companies acquire many new ventures.

The decreased willingness to fund innovative new ventures since the financial crisis is most clear in the venture capital industry. In early October 2008, Sequoia Capital’s presentation entitled “R.I.P. Good Times” (2008) drew attention for its grim outlook on the recession and its outline for an aggressive approach to cut-backs during what they predicted would be a long and “not normal” crisis. The firm encouraged its portfolio companies to manage what could be controlled, namely in aggressively slashing expenses so as to become cash-flow positive as soon as possible. This presentation served as a harsh reminder to venture capitalists that the field was not insulated from the crisis at large. In response, start-ups like Portland, Oregon based Jive Software, took action – 25 of Jive’s 150 full-time employees were laid off and projects were cut in the hope of riding out the recession (Miller, 7 April, 2009).

These anecdotal observations are borne out in the data on venture investments. Venture-capital investment dropped 30% in the fourth quarter of 2008 to its lowest level since 2005 (Tam, 2009). Figure 1 depicts the pattern of venture investment in the United States. in recent months. Nor has there been much evidence of a sustained recovery in 2009. According to industry statistics, volume and average disclosed value were both down.

Raising money for new entrepreneurial endeavours from other sources during the credit crunch has proven to be nearly impossible as a consequence of the financial markets collapsing. Pension funds, (university) endowments and wealthy individual investors are reluctant to fund ventures in today’s economy. Increasingly risk-adverse investors opt to support companies they have already invested in instead of committing to new obligations. “As a result,” Claire Cain Miller writes, “investors are funnelling time and money into existing portfolio companies instead of a new generation of start-ups” (18 April, 2009). This retreat by institutions affects not just entrepreneurs but the venture funds themselves. Many VCs are concerned that retreating investors may “renege on commitments they’ve already made” (Nuttall and Walters, 2008) because they are unable to come up with the cash for capital calls. Not surprisingly, credit from banks for entrepreneurial ventures ranges from difficult to obtain to out of the question.

The same is true for raising capital through public markets and probably corporations. This decline of activity can be illustrated by Securities Data Company’s compilation of the number of initial public offerings by high-technology firms worldwide. (These were defined as all global IPOs in the following SDC categories: Biotechnology, Computer Equipment, Electronics, Communications, and "Other High-Technology" — Robotics, Lasers, Advanced Materials, and so forth.) The number of offerings between the fourth quarter of 2006 and third quarter of 2007 was 261; between the fourth quarter of 2008 and the third quarter of 2009, the total was 42. Anecdotal accounts suggest that spending by corporations on alliances and venturing programmes has also declined.

More detailed data are available regarding liquidity events for venture-backed firms. In 2008, merely six venture-backed start-ups went public and there were only 260 acquisitions of these firms, down from 86 and 360 in 2007 (NVCA, January. 2009). The most recent report released by NVCA and Thomson Reuters shows that the venture capital market has yet to make a true recovery in terms of exit rates.

According to the October 2009 Venture Backed Exits report, "Venture-backed company exit activity showed little signs of life during the third quarter of 2009 and fell far short of historical norms." The third quarter of 2009 saw only 62 M&A exits, the lowest so far that year, bringing the year to date total to 189, considerably below the total at the same time in 2008. The number of venture-backed IPOs remained tiny as well (NVCA, October 2009). According to National Venture Capital Association president Mark Heesen:

> The most significant impact of the US financial crisis on the venture capital industry has clearly taken place in the exit markets. The inability of our strongest companies to go public and the softening of acquisitions activity continue to have a major ripple effect that now reaches every stage of the venture investment lifecycle (January 2009).

So far, we have focused on the changes in the United States. Europe's venture capital industry is no exception to the ramifications stemming from the financial crisis. According to a position statement published by the European Private Equity and Venture Capital Association (EVCA) on 21 August, 2009, "Europe's venture capital market suffers from significant obstacles and diseconomies of scale," (2009) among other things. Adding to this gloom, "Europe's venture capital scene is rapidly shrinking" (Austin, 2009). In the second quarter, Europe's deals fell for the fourth consecutive quarter to 156, or 24% below the first quarter, while investment dropped 31% to EUR 619.7 million (USD 880.6 million) (Austin, 2009).

While less well-documented, the same appears true more generally for other geographies. While systematic data for Asia and other markets are harder to come by, there appear to have been sharp drop off in venture activity in Australia, New Zealand, India, and the Middle-East. (China, which has experienced a robust recovery on the back of extensive government intervention, appears to be the exception to the worldwide trend.)

2. Entrepreneurship and innovation

While economists and policymakers worldwide have long recognised the importance of technological innovation for growth, the relationship between innovation and entrepreneurship has been appreciated more recently. Today, a substantial body of academic literature suggests that entrepreneurs play an important role in fomenting innovation.

2.a. Initial conjectures

What makes entrepreneurial organisations more or less innovative than established entities? For a long time, the literature on this topic focused solely on the relationship between innovation and firm size, following Schumpeter's (1942) famous conjecture that large firms had an inherent advantage at innovative functions relative to smaller enterprises, due to their ability to capture more the profits associated with these discoveries.

But long before the emergence of modern high-technology industries, some of Schumpeter's contemporaries had some misgivings on the ability of large firms to generate technological innovations. For instance, Jewkes, Sawers, and Stillerman (1958) argued:

> "It is erroneous to suppose that those techniques of large-scale operation and administration which have produced such remarkable results in some branches of industrial manufacture can be applied with equal success to efforts to foster new ideas. The two kinds of organisation are subject to quite different laws. In the one case the aim is to achieve smooth, routine, and faultless repetition, in the other to break through the bonds of routine and of accepted ideas. So that large research organisations can perhaps more easily become self-stultifying than any other type of large organisation, since in a measure they are trying to organise what is least organisable. The director of

a large research institution is confronted with what is perhaps the most subtle task to be found in the whole field of administration"

From the vantage point of 21st century economists, the Schumpeterian hypothesis has not stood the test of time. It turns out to have been the intellectual byproduct of an era that saw large firms and their industrial laboratories (such as IBM, AT&T, and DuPont) replace the independent inventors who accounted for a large part of innovative activity in the late 19th and early 20th century (Lamoreaux and Sokoloff, 2005).

The Schumpeterian hypothesis does not accord with casual empiricism, as in several new industries (medical devices, communication technologies, semiconductors, software), industry leadership is firmly in the hands of relatively young firms whose growth was largely financed by public equity markets (Boston Scientific, Cisco, Intel, and Microsoft). In particular, it appears that small and new firms not only have contributed an important share of research and development themselves, but they also have had in many cases a disproportionate influence by introducing fresh technologies and business models that incumbent firms have struggled to address. Many examples could be offered, from the way in which Craigslist rapidly dominated the classified advertising business that had been a "cash cow" for many newspapers to the success of pioneering biotechnology firms in developing bioengineered products to combat anaemia and diabetes at the time when established drug-makers were largely ignoring the technology.

2.b. Early work

A substantial literature examines the relationship between firm size and innovation, but most systematic tests of Schumpeter's argument have been inconclusive. Much of the work in this literature has sought to relate measures of innovative discoveries — whether R&D expenditures, patents, inventions, or other measures — to firm size. Initial studies were undertaken using the largest manufacturing firms; more recent works have employed larger samples and more disaggregated data (*e.g.,* studies employing data on firms' specific lines of business).

These studies have been handicapped by the difficulty of measuring innovative inputs and outputs, as well as the challenges of creating a sample that is free of selection biases and other estimation problems. Despite the improved methodology of recent studies, the results have remained inconclusive: even when a significant relationship between firm size and innovation has been found, it has had little economic significance. For instance, Cohen, Levin, and Mowery (1987) concluded that a doubling of firm size only increased the ratio of R&D to sales by 0.2% [3]

One of the relatively few empirical regularities emerging from studies of technological innovation is the critical role played by small firms and new entrants in certain industries. The role of entrants — typically *de novo* start-ups — in emerging industries was highlighted, for instance, in Acs and Audretsch (1988). They documented that the contribution of small firms to innovation was a function of industry conditions: the contribution was greatest in immature industries which were relatively unconcentrated. In follow on work (1987) they show large firms tend to have the relative innovative advantage in capital intensive and highly unionized industries. Small firms tend to have relative advantage in highly innovative industries that are composed of a relatively high proportion of large firms.

These findings suggested that entrepreneurs and small firms often played a key role in observing where new technologies could be applied to meet customer needs, and rapidly introducing products. A more nuanced view is taken by Sorenson and Stuart (2000), who argue that in the biotechnology and

3 While a detailed review of this literature is beyond the scope of this piece, the interested reader can turn to surveys by Baldwin and Scott (1987) and Cohen and Levin (1989).

semiconductor industries, older firms innovate at a higher rate, but these innovations increasingly trail behind the technological frontier, focusing their innovative activities instead on well-established rather than up-and-coming technological domains.

What explains the relative failure of the empirical programme started by Schumpeter's mid-century prophecy? An important reason is institutional change in the form of the emergence of vibrant "markets for ideas" that heralded a new division of innovative labour between large and small firms (Arora *et al*., 2001; Gans and Stern, 2000; Gans *et al*., 2002; Teece, 1986). If would-be innovators have the ability to co-operate with incumbent firms to appropriate the returns from technological innovation, regressing R&D expenditures on firm sales will not be very illuminating.

Another early line of work, rather than asking whether large firms invest more in R&D relative to small ones, focuses on evaluating theoretically and empirically the costs of market incumbency on the ability to innovate.

A distinct stream of research explores the conditions under which market incumbents can adapt in the face of technological change. Here there has been a closer connection between theoretical work and empirical studies. The theoretical debate is well known, and has been reviewed elsewhere (*e.g*., Reinganum, 1989). In brief, models of technology races make sharply different predictions on the innovation incentives of incumbents and entrants depending on (i) the nature of uncertainty — *i.e*., can investment shift the timing of the new product's introduction? — and (ii) whether the innovation is radical or incremental — *i.e.* is the new product so obviously superior that demand for the old product disappears (Gilbert and Newberry, 1982; Reinganum, 1983)?

Because these features are hard for researchers to measure, empirical work has attempted to test the implications of racing models, rather than the models directly. Lerner (1997), in his empirical examination of the disk drive industry, is a good example of this approach. For each product generation, he finds that firms who followed the leader in the previous generation display the greatest propensity to innovate. Interestingly, the same pattern does not exist in situations where strategic incentives are muted, as is the case when the firm is a division within a vertically-integrated firm. Lerner interprets these findings as providing support for Reinganum's model of technological racing, but it is not clear that innovation in the disk-drive industry should be construed as radical. In particular, the old and new generation of products do coexist for a period of time, because they typically appeal to distinct customer segments.

Christensen (1997) provides a different interpretation of the same phenomenon. According to his analysis, the new product generation initially poorly serves the needs of the incumbent's customers, but its quality eventually catches up. This presents an ideal situation for entrants to exploit incumbents' "blind spots," which stem from their single-minded focus on existing customers. Christensen goes on to recommend that established firms systematically create "skunk-works" to incubate their next generation of products, far from the paralysing influence of the old business.

Economists will naturally be skeptical of such a blanket recommendation. The disk drive industry is characterized by a weak appropriability regime (patents can be invented around), and it would be hazardous for an entrant to try to licence an innovation to an established firm. The conclusions may be therefore highly contingent on particular industry characteristics. Nonetheless, the reasons behind the apparent bias of incumbents in favour of "home-grown" technology is a recurrent theme of the managerial literature, and its persistence and effects are worthy of attention by economists.

Other strands of the managerial literature put forth a conception of radical and incremental innovation based on supply-side considerations: A radical innovation is one that destroys, or at least does not build on, the technological capabilities of incumbent firms (Tushman and Anderson, 1986). In that studies of the photolithographic industry, Henderson (1993) and Henderson and Clark (1990) note that it is entirely possible for innovations to be incremental in an economic sense, but radical in an organisational sense, and they provide evidence that incumbents have particular difficulty adapting to such “architectural” change. Using qualitative evidence, they explore the mechanisms that might explain the incumbents’ lack of success in commercialising architectural innovations. They advance two types of explanations. The first focuses on dysfunctional incentives and stilted communication channels; the second emphasises behavioural biases that affect the managers of incumbent firms.

Some support for these claims has been provided in recent years from the “real world.” The most compelling evidence is the transformation of the corporate research and development system. The central corporate R&D laboratory was a dominant feature of the innovation landscape in the United States for most of the 20th century. While the concept of the centralised laboratory originated in the German chemical industry, US corporations adopted it with enthusiasm by mid-century. These campus-like facilities employed many thousands of researchers, many of whom were free to pursue fundamental science with little direct commercial applicability, most notably Bell Laboratories (with 11 Nobel Laureates) and IBM Central Research (with 5).

Beginning in the early 1990s, however, American corporations began fundamentally rethinking the role of these centralised research facilities (see, for example, the discussions in Rosenbloom and Spencer (1996) and Chesbrough (2003)). Reflecting both a perception of disappointing commercial returns and intensified competitive pressures, firms undertook a variety of changes to these facilities. These included both paring the size of central research facilities in favour of divisional laboratories and relying much more heavily on what has been termed “open innovation,” *i.e.*, alliances with and acquisitions of smaller firms.

To economists, however, these changes are not surprising. Observers such as Jensen (1993) have contrasted the incentives within corporate research facilities unfavourably with those offered by venture capitalists. He suggests that had higher-powered incentives been offered, some of the poor performance of research-intensive firms would have been avoided.

This transformation suggests that whatever the vicissitudes brought about by the financial crisis, the opportunities for high-potential entrepreneurial firms is likely to increase in the medium and longer term. The model of growing entrepreneurial companies for full or partial acquisition by larger firms — as has been practiced for many years in the computer networking business, for instance — is likely to be a growing segment of the exit markets in the years to come. And given the fact that corporate research spending, both in the United States and globally, is many times the magnitude of venture capital investment, the size of the opportunity is likely to be substantial.

Much of the research into the question of entrepreneurship and innovation since this early work has been devoted to fleshing out the intuition of Jewkes and his co-authors: economists and other social scientists have studied how other organisational characteristics impinge on the process of technological innovation.

2.c. Recent work

More recent work has gone beyond seeking to document the failure of large firms to innovate or estimating relationship between firm size and innovation. Rather it has sought to understand the reasons why we see such patterns of innovations. Economists have focused on four main lines of explanations: incentives, knowledge spillovers, employee mobility, and organisational structure.

2.c.i. Incentives

Firms provide incentives to their employees in all realms of economic life. In recent years, economists have come to a greater appreciation of why the design of incentive systems for innovative tasks differs from that appropriate for “humdrum” tasks, and why this may represent an advantage for entrepreneurial firms.

Holmstrom (1989) provides a number of reasons that make the provision of incentives for innovation a difficult one, particularly in larger firms. First, innovation projects are risky and unpredictable; second, they are long-term and multistage; third, it might not be clear *ex ante* what is the correct action for the agent to take; and finally, they tend to be idiosyncratic and difficult to compare to other projects. To this list, one can add two additional characteristics: innovators tend to bring to their labour a certain degree of intrinsic motivation; and lastly, innovation is very often a team activity. This perspective suggests that entrepreneurial firms, whose activities are typically more focused, are likely to be able to make more use of incentive pay and the benefits it brings.

Manso (2006) is the first economist to formalise the trade-off between the exploration of untested actions and the exploitation of well-known actions, which has long been a focus of organisation theorists (March, 1991). He uses a class of decision problems called bandit problems, in which the agent does not know the true distribution of payoffs of the available actions. Exploration of new untested actions reveals information about potentially superior actions, but is also likely to waste time with inferior actions. Exploitation of wellknown actions ensures reasonable payoffs, but may prevent the discovery of superior actions. Embedding the bandit problem into a traditional principal-agent model, Manso focuses on the features of incentive schemes that encourage exploration. He finds striking departures from the standard pay-for-performance contracts that are optimal when the principal is focused on eliciting effort for known actions. The principal should tolerate early failure and reward long-term success; she should provide some job security to the agent; and should provide feedback on performance to the agent.

Ederer and Manso (2007) devise a laboratory experiment in which subjects are randomly assigned to incentive plans, including (i) a flat wage; (ii) a standard pay-for-performance contract; and (iii) a pay-for-future performance contract. They find that forward-looking incentives result in more exploration and higher profits. These results suggest that appropriately designed incentives do not lead to a "crowding out" effect, contrary to earlier arguments that incentives are likely to undermine creativity (*e.g.* Amabile (1996)).

One branch of the literature provides an incentive-based explanation for the dominance of entrepreneurial firms in new industries. Aron and Lazear (1990) present a model in which incentive schemes drive new firms to pursue high variance strategies and hence are more likely to introduce new products. Prusa and Schmitz (1994) test their argument by examining the introduction of new software programmes. The authors suggest that new firms appear to be more effective at creating new software categories, while established firms have a comparative advantage in extending existing product lines. It should be noted that models like Aron and Lazear’s pertain to innovation generally, not necessarily *technological* innovation.

Another generic theme is that of incentive balance, when several tasks compete for the agent’s attention, but the principal’s ability to infer effort from output is much higher for one set of tasks, relative to another set of tasks. The main result from this literature is that it may be optimal to provide low-powered incentives in such situations, to avoid distorting the agent’s allocation of effort towards the task that is easier to meter, and high-powered ones in other situations. Again, this may explain why arrangements in major corporations and entrepreneurial firms are different.

Cockburn, Stern and Henderson (1999) illustrate the implications of this principle in the setting of drug discovery R&D. Pharmaceutical firms would like their researchers to generate many useful patents, but if the scientists are not connected to sources of knowledge located outside the firm, their creativity will eventually run dry. Conversely, if the scientists solely focus on staying on the frontier of science, the firm will find itself running a (possibly very good) biology department, but will have little tangible output (actual new drugs) to show for its R&D investment. Cockburn *et al.* show that pharmaceutical firms resolve this tension by keeping incentives for basic and applied output in balance. On the one hand, scientists will be rewarded and promoted based on their *individual* standing in their scientific sub-field, using traditional academic criteria, such as publications and citations. On the other hand, research *teams* will be rewarded on the basis of their applied output. In practical terms, a group which generates more useful patents than expected in a given year will see its budget increase the following year. Cockburn *et al*. find that firms tend to adopt both or none of these practices, rather than adopting one without the other.

Innovation settings differ from more traditional ones because employee-technologists often work on something because they find it personally rewarding. Intrinsic motivation is important because it has implications for job design and wage setting. In a fascinating survey of life scientists on the job market, Stern (2004) finds that pharmaceutical firms who give their scientists freedom to choose their own projects and otherwise remain connected to "open science" pay 15% less on average, holding scientist ability constant. This provides a rationale for firms to harness their employees' preferences in the way they organise research activities, in addition to the crowding-out effect of extrinsic incentives often stressed by psychologists (Amabile, 1993).

Of course, firms need to balance the wage savings associated with employee autonomy against the leakages associated with open innovation models. As it turns out, the management of knowledge spillovers from innovative activities is a topic that has also received considerable attention.

2.c.ii. Spillovers of Knowledge

In his famous 1962 essay, Kenneth Arrow focused economists' attention on the non-rival nature of knowledge and the attendant disclosure problem. The probability that some of the knowledge generated internally will leak out to their competitors is high. Ever since, economists have been focused on firms' ability to actively manage knowledge spillovers. Again, this has suggested an advantage for entrepreneurial firms relative to their more established peers.

The starting point for the discussion is that knowledge is not as public a good as initially thought, and therefore distance between the emitter and the receiver of knowledge matters in determining the extent of spillovers. Jaffe, *et al.* (1993) observed that despite their ethereal nature, knowledge spillovers might leave a paper trail in the form of citations to prior art recorded in patents. By constructing a large dataset of patents and matching the location of inventors for both cited and citing patents, they documented that these citation patterns exhibit a pronounced degree of localisation.[4]

However, physical proximity is not necessarily the only, or even the most relevant concept of distance that economists should consider when attempting to estimate the magnitude of knowledge spillovers. To the three dimensions of physical space, it seems worthwhile to add "technological space": advances in the state of knowledge in one particular technological area are likely to spur relatively more developments in technological areas that are thematically related. Jaffe (1986) was the first to construct a measure of technological distance between firms by using the distribution of firms' innovative efforts across patent

4 As documented by Thompson and Fox-Kean (2005), this exercise is fraught with difficulties because of the difficulty to find non-citing patents that can serve as a control group and capture the agglomeration patterns that are due to factors other than knowledge spillovers.

classes, and he found that the R&D productivity of a local firm was indeed positively correlated with the R&D of technological neighbours.

Social distance might also impinge on the extent of spillovers. Here the network metaphor is particularly apt, whether one thinks about degrees of separation between scientists in a co-authorship network, of the relationship between a corporate parent and its subsidiaries, or about the vertical linkages between buyers and suppliers. Adams and Jaffe (1996), focusing on the chemical industry, showed that the effects of parent firm R&D on plant-level productivity decreases with both geographic and technological distance between the research lab and the plants. Moreover, spillovers from technologically-related firms are significant in magnitude but are "diluted" by the firms' own R&D intensity. This article stands out in the vast empirical literature because it simultaneously attends to the three concepts of distance mentioned above.

A second fundamental idea in the study of knowledge spillovers is the concept of *absorptive capacity*: absorbing spillovers from other firms requires doing research yourself (Cohen and Levinthal, 1989, 1990). Using a dataset that combines FTC line of business information with Levin *et al.* (1987) survey data, these authors find that spillovers from input suppliers can be absorbed with less R&D investment than spillovers from government and university labs. In the setting of pharmaceutical drug discovery, Cockburn and Henderson (1998) document strong correlations between the extent of ties between firms and academic science (mostly through co-authorship of scientific articles) and these same firms' research productivity. Moreover, building absorptive capacity has implications for the organisation of R&D activity. Henderson and Cockburn (1996) use detailed data at the research programme level from ten pharmaceutical firms and show that firms that adopted the practices of "open science" to motivate and reward scientists increased their research productivity (as measured by important patents by dollars invested) significantly during the 1980s.

A more recent literature stresses that there are other ways — beyond performing basic R&D — for firms to absorb outside knowledge. In a fascinating case study of the semi-conductor industry, Lim (2006) shows that IBM's competitors were able to quickly imitate its design of copper interconnects by working closely with equipment suppliers, by collaborating with some key academic labs, and by hiring newly-minted PhDs and postdoctoral fellows in the relevant scientific sub-fields.

While most of the literature has focused on whether knowledge spillovers exist, some work has asked who takes particular advantage of these information flows. And here, it appears, entrepreneurial firms have an advantage: these firms, which frequently draw key staff members from a variety of local employers, might be anticipated to be particularly well-positioned to capture spillovers. The most well-known empirical evidence in support of this claim pertains to the role of scientific superstars documented by Zucker, *et al*. (1998). These authors document a robust correlation between the rates of founding of new biotechnology firms and proximity to scientists who are leaders in the relevant sub-fields of biology.

2.c.iii. Employee mobility

A closely related area where entrepreneurial firms appear to have a substantial advantage is in garnering benefits from employee mobility.

Our appreciation of this factor stems from the seminal study of the computer and semi-conductor cluster in Silicon Valley by Annalee Saxenian (1994), who drew the attention of economists to the high rates of job hopping among engineers. She ascribed the sustained success of new Silicon Valley firms to the rapid movement of technical professionals between firms in the region and pointed out that an accident of Californian legal history precluded the enforcement of non-compete agreements in the state. Since then, an ever-expanding empirical literature has documented more systematically that job hopping is indeed a source of knowledge spillovers, and that these spillovers tend to be geographically localized (Almeida and Kogut, 1999; Fallick *et al*., 2006).

Gompers, *et al.* (2005) in contrast explore the spin-off process. They hypothesise that individuals already working for entrepreneurial firms, particularly those already backed by venture capitalists and located in hotbeds of venture capital activity, may find launching their own venture less daunting than others might for a number of reasons: they have already been exposed to a network of suppliers of labour, goods, and capital, as well as a network of customers (Saxenian (1994)), they have already "learnt by doing" how to establish an entrepreneurial firm, or individuals with a higher taste for risky activities may have already found their way to entrepreneurial firms, consistent with the models of the sorting processes (Jovanovic (1979), Holmes and Schmitz (1990) and Gromb and Scharfstein (2002)). After systematically examining which publicly traded firms had employees depart to start new venture backed firms, the authors conclude the findings appear to be more consistent with the view that entrepreneurial learning and networks are critical factors in the creation of venture capital backed firms.

Of course, one might think that established companies would try to prevent such movements. Pakes and Nitzan (1983) present a model in which engineers bond themselves to their firms by accepting lower entry wages. Moen (2005), using matched employee/employer data from Norway, compares the wage-experience profiles of engineers and non-technical white collar workers and finds that they are steeper for the former group of employees than for the latter. An alternative, more direct strategy is to focus instead on policy changes that affect rates of mobility among technical personnel. Marx *et al*. (2007) exploit Michigan's inadvertent reversal of its non-compete enforcement legislation to demonstrate that non-competes decrease inventor mobility by 34%, particularly to smaller firms.

2.c.iv. Organisational structure

In their effort to broaden the range of organisational characteristics that impinge on the innovation process, economists and other social scientists have recently focused on various aspects of organisational structure. Here, too, the literature suggests that entrepreneurial firms may have an advantage.

Managerial scholars have long debated the relative merits of centralised R&D labs that characterize major corporations and decentralised R&D activities that many venture-backed firms have (Rosenbloom and Spencer, 1996). Centralised R&D labs can potentially engage in non-local search activities and focus on long-term projects; but they run the risk of slowly evolving into "ivory tower" academic departments. Decentralising R&D investment into divisions prevents employee technologists from losing sight of market imperatives, but might result in a slow degradation of technological and scientific competencies.

Lerner and Wulf (2007) combine information about structure with data on incentives provided to corporate R&D managers among *Fortune 500* firms. They find that long term incentives (stock options and restricted stock) result in patents than are more heavily cited, but this relationship is driven solely by firms with centralised R&D. This study suggests that aligning the incentives of corporate R&D staff with those of the firm as a whole can mitigate the risk that research output loses relevance, with important caveats. Patent citations are far from an ideal measure of the relevance of the research to the firm's product markets: sales from innovative products would be a more appropriate metric. The relative virtues of centralised and decentralised R&D structures remains a relatively open question.

An aspect of organisational structure whose impact on entrepreneurial firms is less controversial is venture capital organisations, that is, independently managed, dedicated capital focusing on equity or equity-linked investments in privately held, high-growth companies [5]

Venture capital has attracted extensive theoretical scrutiny. These works suggest that venture capitalists promote innovation by mitigating agency conflicts between entrepreneurs and investors. The improvement in efficiency might be due to the active monitoring and advice that is provided (Cornelli and Yosha, 2003; Hellmann, 1998; Marx, 1994), the screening mechanisms employed (Chan, 1983), the incentives to exit (Berglöf, 1994), the proper syndication of the investment (Admati and Pfleiderer, 1994), or investment staging (Bergmann and Hege, 1998; Sahlman, 1990).

Empirical academic studies have been of two types. First, a large body of literature has sought to understand what venture capitalists do: that is, how they address agency problems.

If monitoring and information gathering are important – as models such as those of Amit, Glosten and Muller (1990) and Chan (1983) suggest – venture capitalists should invest in firms where asymmetric problems are likely, such as early-stage and high-technology firms with intangible assets. The capital constraints faced by these companies will be large and these investors will address them.

Gompers (1995) shows that venture capitalists concentrate investments in early-stage companies and high-technology industries where informational asymmetries are significant and monitoring is valuable. Moreover, he argues that staged capital infusion is the most potent control mechanism a venture capitalist can employ. The shorter the duration of an individual round of financing, the more frequently the venture capitalist monitors the entrepreneur's progress. The duration of funding should decline and the frequency of re-evaluation increase when the venture capitalist believes that conflicts with the entrepreneur are likely. He finds that early-stage firms receive significantly less money per round. Increases in asset tangibility are associated with longer financing duration and reduce monitoring intensity, presumably because such assets increase the salvage value of the firm if the enterprise fails.

In a related paper, Kaplan and Strömberg (2003) document how venture capitalists allocate control and ownership rights contingent on financial and non-financial performance. If a portfolio company performs poorly, venture capitalists obtain full control. As performance improves, the entrepreneur obtains more control. If the firm does well, the venture capitalists relinquish most of their control rights but retain their equity stake.

Related evidence comes from Hsu (2004), who studies the price entrepreneurs pay to be associated with reputable venture capitalists. He analyses firms which received financing offers from multiple venture capitalists. Hsu shows that high investor experience is associated with a substantial discount in firm valuation.

Venture capitalists usually make investments with peers. The lead venture firm involves other venture firms. One critical rationale for syndication in the venture industry is that peers provide a second opinion on the investment opportunity and limit the danger of funding bad deals. Lerner (1994a) finds that in the early investment rounds experienced venture capitalists tend to syndicate only with venture firms that have similar experience. He argues that, if a venture capitalist were looking for a second opinion, then he would want to get one from someone of similar or greater ability, certainly not from someone of lesser ability.

[5] It may well be that other forms of entrepreneurial finance, such as individual angels and corporate venturing initiatives have the same salutary effects. But these have been much less well studied in the finance literature (largely due to an inability to obtain systematic data), and as a result our conclusions here must be much more tentative.

The advice and support provided by venture capitalists is often embodied in their role on the firm's board of directors. Lerner (1995) examines whether venture capitalists' representation on the boards of the private firms in their portfolios is greater when the need for oversight is larger, looking at changes in board membership around the replacement of CEOs. He finds that an average of 1.75 venture capitalists are added to the board between financing rounds when a firm's CEO is replaced in the interval; between other rounds 0.24 venture directors are added. No differences are found in the addition of other outside directors.

Hochberg (2005) studies the influence of venture capitalists on the governance of a firm following its initial public offering (IPO). Venture-backed firms manage earnings less in the IPO year, as measured by discretionary accounting accruals. Venture-backed firms also experience a stronger wealth effect when they adopt a poison pill, which implies that investors are less worried that the poison pill will entrench management at the expense of shareholders. Finally, venture-backed firms more frequently have independent boards and audit and compensation committees, as well as separate CEOs and chairmen.

While theorists have suggested a variety of mechanisms by which venture capital may affect innovation, direct tests of the impact of venture financing on innovation have encountered challenges. It might be thought that establishing a relationship between venture capital and innovation would be straightforward. For instance, one could look in regressions across industries and time whether, controlling for 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 was more venture capital, not because the venture capital caused the innovation, but rather because the venture capitalists reacted to some fundamental technological shock which was sure to lead to more innovation. To date, only a handful of papers have attempted to address these challenging issues.

The first of these papers, Hellmann and Puri (2000), examines a sample of 170 recently formed firms in Silicon Valley, including both venture-backed and non-venture firms. Using questionnaire responses, they find empirical evidence that venture capital financing is related to product market strategies and outcomes of startups. 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 investor type and product market dimensions, and a role of venture capital in encouraging innovative companies. Given the small size of the sample and the limited data, they 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 whether these patterns 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 Labour clarified the Employee Retirement Income Security Act, 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. They 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 to 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 addressing these causality concerns, 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% of corporate R&D from 1983 to 1992, is responsible for a much greater share — perhaps10% — of US. industrial innovations in this decade. These findings have been supported by a recent working paper by Mollica and Zingales (2007), who also use an instrumental variable approach based on state pension fund resources to look at the relationship between venture capital and innovation and find a strong relationship.

Some of the most interesting theoretical work in recent years has focused not on the question of whether venture capitalists spur innovation, but rather on the societal *consequences* of the relationship between venture-backed entrepreneurship and innovation. Landier (2006) presents a model in which entrepreneurial ventures succeed or fail on the basis of ability and luck.[6] He argues that as the venture progresses, the entrepreneur is likely to learn about the likely eventual success of the venture, but that the decision to continue or abandon the venture will not be the same in all environments. In particular, the decision depends critically on how expensive it would be to raise capital for a new venture from investors after a failure. In this setting, Landier shows, multiple equilibria can arise. If the cost of capital for a new venture after a failure is not very high, entrepreneurs will be willing to readily abandon ventures, and failure is commonplace but not very costly. Alternatively, if the cost of capital for failed entrepreneurs is high, only extremely poor projects will be abandoned. Thus, societies may differ dramatically in the prevalence of experimentation in high-risk, innovative ventures.

As noted in footnote 4, the literature on intermediaries to finance early-stage entrepreneurs has been largely focused on the venture capital firm. There are a variety of alternative options, most notably individual angels and corporate venturing initiatives. While these are less scrutinized, the preliminary evidence suggests that they have many of the same salutary effects. For instance, Wong, Bhatia, and Freeman (2009) show that many of the same transaction structures seen in venture agreements are also found in contracts by angels, where they presumably have the same salutary effects. Gompers and Lerner (2000) examine over 30.000 transactions by corporate and other venture organisations. Corporate venture investments in entrepreneurial firms appear to be at least as successful (using such measures as the probability of the portfolio firm going public) as those backed by independent venture organisations, particularly when there is a strategic overlap between the corporate parent and the portfolio firm. Again, these results are consistent with the notion that a variety of intermediaries can play a valuable role in overcoming the problems that make young entrepreneurs difficult to fund.

3. Market cycles' impact on innovation and entrepreneurship

We now turn to understanding the consequences of market cycles for these activities. To what extent are innovation and entrepreneurship likely to be affected by these cycles? Before we plunge into this question, we need to step back to consider the way that financial considerations impact on the innovation investment decision.

6 See also Gromb and Scharfstein (2002) for a thoughtful theoretical analysis that touches on many of these issues.

3.a. Why financial conditions might matter

An initial consideration of the classic finance literature might suggest that changing financial market conditions should not affect the availability of capital to finance the development of promising innovations. But a more recent literature suggests this view is simplistic.

3.a.i. The efficient markets baseline

Efficient markets theory might suggest that financial market conditions might not matter at all. As articulated by Fama (1998) and followers, the efficient market hypothesis, particularly in its strong form, implies that stock prices reflect all information, whether privately or publicly known. As a result, no investor can earn excess returns. As a result, all firms with positive net present value investments — for instance, with a prototype that needs financing to be developed — should be able to raise the needed capital.

One of the implications of the well-known Modigliani-Miller theorem (1958, 1961) is that a firm choosing the optimal level of investment should be indifferent to its capital structure: thus, the choice of debt and equity should not matter for firms. Moreover, the last dollar spent on each type of investment, including innovation, should yield the same expected rate of return. An abundant literature, both theoretical and empirical, has questioned the bases for these theorems, but they remain a useful starting point.

3.a.ii. Complications

With respect to R&D investment, economic theory advances a plethora of reasons why there might be a gap between the external and internal costs of capital, and why availability of external financing of different types may matter.

These can be divided into three main types:

1. Asymmetric information between inventor/entrepreneur and investor.
2. Moral hazard on the part of the inventor/entrepreneur arising from the separation of ownership and management.
3. Tax considerations that drive a wedge between external finance and finance by retained earnings.

We discuss each of these reasons in the sections below.

1) Information asymmetries

In the innovation setting, the asymmetric information problem refers to the fact that an inventor frequently has better information about the likelihood of success and the nature of the contemplated innovation project than potential investors. Therefore, the marketplace for financing the development of innovative ideas looks like the “lemons market" modeled by Akerlof (1970). The lemons' premium for R&D will be higher than that for ordinary investment because investors have more difficulty distinguishing good projects from bad when the projects are long-term R&D investments than when they are more short-term or low-risk projects (Leland and Pyle, 1977). When the levels of R&D expenditure are a highly observable signal, as it is under current US. and UK. rules, we might expect that the lemons' problem is somewhat mitigated, but certainly not eliminated.[7]

[7] Since 1974, publicly traded firms in the United States have been required to report their total R&D expenditures in their annual reports and 10-K filings with the SEC, under FASB rule No 2, issued

In the most extreme version of the lemons model, the market for R&D projects may disappear entirely if the asymmetric information problem is too great. Informal evidence suggests that some potential innovators believe this to be the case in fact.

Reducing information asymmetry via fuller disclosure is of limited effectiveness in this arena, due to the ease of imitation of inventive ideas. Firms are reluctant to reveal their innovative ideas to the marketplace and the fact that there could be a substantial cost to revealing information to their competitors reduces the quality of the signal they can make about a potential project (Bhattacharya and Ritter, 1983; Anton and Yao, 1998). Thus the implication of asymmetric information coupled with the costliness of mitigating the problem is that firms and inventors will face a higher cost of external than internal capital for R&D due to the lemons' premium.

The asymmetric information that entrepreneurs face may vary over time, as shown by Bernanke and Gertler (1995). The paper develops a simple neoclassical model of the business cycle in which the condition of entrepreneurs' balance sheets is a consequence — and driver — of economic dynamics. They hypothesise that there are information gaps between the entrepreneurs who organise and manage investments and the savers from whom they borrow. If borrowers have more net worth, and thus can put more capital in the transaction, these information problems will be alleviated. But during periods of financial "distress" (when borrower net worth is low), these problems are serious. As a result, entrepreneurs' healthy balance sheets during good times will expand investment demand, and thus in turn tend to amplify the upturn; while weakened balance sheets in bad times have the opposite effect. In a related model, Francois and Lloyd-Ellis (2009) develop a theory of endogenous, cyclical growth, showing that entrepreneurial innovations can drive regular booms and downturns as a part of the long-run growth process.

Some empirical support for this proposition that asymmetric information is a major problem exists, mostly in the form of event studies that measure the market response to announcements of new debt or share issues.[8] Both Alam and Walton (1995) and Zantout (1997) find higher abnormal returns to firm shares following new debt issues when the firm is more R&D-intensive. The argument is that the acquisition of new sources of financing is good news when the firm has an asymmetric information problem because of its R&D strategy. Similarly, Szewcxyk, Tsetsekos, and Zantout (1996) find that investment opportunities (as proxied by Tobin's q) explain R&D-associated abnormal returns, and that these returns are higher when the firm is highly leveraged, implying a higher required rate of return for debt finance in equilibrium. Aghion, *et al.* (2008) argue that these information problems preclude French firms that would otherwise increase their R&D spending during economic downturns from doing so, thereby intensifying economic cycles.

2) Moral hazard

Moral hazard in R&D investing arises in the usual way: modern industrial firms normally have separation of ownership and management. This leads to a principal-agent problem when the goals of the two conflict, which can result in investment strategies that are not share value maximising. Two possible scenarios may co-exist: one is the usual tendency of managers to spend on activities that benefit them (growing the firm beyond efficient scale, nicer offices, etc.) and the second is a reluctance of risk-averse

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October 1974. In 1989, a new accounting standard, SSAP 13, obligated similar disclosures in the United Kingdom Most continental European countries have not had such a requirement in the past, but this is changing as harmonised international standards come into force.

8 See Campbell, Lo, and McKinlay (1996) for a description of this methodology, which infers the value of a firm's action when it is publicly announced by examining the market returns to a share of the firm's stock in the period surrounding the announcement.

managers to invest in uncertain R&D projects. Agency costs of the first type may be avoided by reducing the amount of free cash flow available to the managers by leveraging the firm, but this in turn forces them to use the higher cost external funds to finance R&D (Jensen and Meckling, 1976). In some cases, these conflicts may be insoluble, which leads to an unwillingness to fund entrepreneurs: for instance, Rampini (2004) argues that the presence of agency problems may explain why many more entrepreneurs are funded during boom periods.

According to the second type of principal-agent conflict, managers are more risk averse than shareholders and avoid R&D projects that will increase the riskiness of the firm. If bankruptcy is a possibility, both managers whose opportunity cost is lower than their present earnings and potential bondholders may wish to avoid variance-increasing projects which shareholders would like to undertake. The argument of the theory is that long-term investments can suffer in this case. The optimal solution to this type of agency cost would be to increase the long-term incentives faced by the manager rather than reducing free cash flow.

Evidence on the importance of agency costs as they relate to R&D takes several forms. Several researchers have studied the impact of anti-takeover amendments (which arguably increase managerial security and willingness to take on risk while reducing managerial discipline) on R&D investment and firm value. Meulbroek, *et al.* (1992) and Johnson and Rao (1997) find that such amendments are not followed by cuts in R&D, while Pugh, Jahara, and Oswald (1999) find that adoption of an Employee Stock Ownership Plan (ESOP), which is a form of anti-takeover protection, is followed by R&D increases. Cho (1992) finds that R&D intensity increases with the share that managerial shareholdings represent of the manager's wealth and interprets this as incentive pay mitigating agency costs and inducing long-term investment.

Some have argued that institutional ownership of the managerial firm can reduce the agency costs due to free-riding by owners that is a feature of the governance of firms with diffuse ownership structure, while others have held that such ownership pays too much attention to short-term earnings and therefore discourages long-term investments. Institutions such as mutual and pension funds often control somewhat larger blocks of shares than individuals, making monitoring firm and manager behaviour a more effective and more rewarding activity for these organisations.

There is some limited evidence that this may indeed be the case. Eng and Shackell (2001) find that firms adopting long-term performance plans for their managers do not increase their R&D spending but that institutional ownership is associated with higher R&D; R&D firms tend not to be held by banks and insurance companies. Majumdar and Nagarajan (1997) find that high institutional investor ownership does not lead to short-term behaviour on the part of the firm, in particular, it does not lead to cuts in R&D spending. Francis and Smith (1995) find that diffusely held firms are less innovative, implying that monitoring alleviates agency costs and enables investment in innovation.

Although the evidence summarised above is fairly clear and indicates that long term incentives for managers can encourage R&D and that institutional ownership does not necessarily discourage R&D investment, it is fairly silent on the magnitude of these effects, and whether these governance features truly close the agency cost-induced gap between the cost of capital and the return to R&D.

3) Taxes

Tax considerations that yield variations in the cost of capital across source of finance have been well articulated by Auerbach (1984) among others. He argued that under the US. tax system during most of its history, the cost of financing new investment by debt has been less than that of financing it by retained earnings, which is in turn less than that of issuing new shares. This is due to the fact that interest is deductible at the corporate level, while retained earnings avoids personal tax on dividends, but ultimately faces capital gains taxes.[9]

It is also true that the tax treatment of R&D in most OECD economies is very different from that of other kinds of investment: because R&D is expensed as it is incurred, the effective tax rate on R&D assets is lower than that on either plant or equipment, with or without an R&D tax credit in place. This effectively means that the economic depreciation of R&D assets is considerably less than the depreciation allowed for tax purposes — which is 100% —so that the required rate of return for such investment would be lower. In addition some countries offer a tax credit or subsidy to R&D spending, which can reduce the after-tax cost of capital even further.[10]

The conclusion from this section is that the presence of either asymmetric information or a principal-agent conflict implies that new debt or equity finance will be relatively more expensive for R&D than for ordinary investment, and that considerations such as lack of collateral further reduce the possibility of debt finance. Together, these arguments suggest an important role for retained earnings in the R&D investment decision, independent of their value as a signal of future profitability. In fact, as has been argued by both Hall (1992) and Himmelberg and Petersen (1994), there is good reason to think that positive cash flow may be more important for R&D than for ordinary investment. The next section now turns to the specific setting of entrepreneurial finance, and asks how the dynamics may differ in this particular environment.

3.b. Cycles in entrepreneurial finance

The recent changes in the entrepreneurial finance market we alluded to in the introduction have been far from the first of such cycles in the venture market. Figures 2 and 3 depict one manifestation of this phenomenon: the changing amount of venture capital funds raised worldwide and the returns from venture funds formed in different years (that is, of different vintage years) in the United States and Europe.

Figure 2 deserves some additional discussion. This figure is compiled from various publications and websites of the Canadian, European, Israeli, and US. (National) venture capital associations, as well as those of the *Asian Venture Capital Journal*. In some nations where venture capital investments are not clearly delineated, I employ data on seed and start-up investments.

Four clear patterns emerge from this chart:

- In general, venture markets over the past two decades have moved in parallel. Accelerating growth in the 1990s was replaced by a rapid decline in the early 2000s. Funds raised for much of this decade have been stagnant in inflation-adjusted terms.

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9 These inequalities rely on the assumptions that *a)* interest expense is deductible at the corporate level, while dividend payments are not, *b)* the returns from the investment made will be retained by the firm and eventually taxed at the capital gains rate rather than the rate on ordinary income, and *c)* shareholders normally pay tax at a higher rate on retained earnings that are paid out than on those retained by the firm and invested. A detailed discussion of tax regimes in different countries is beyond the scope of this survey, but it is quite common in several countries for long-term capital gains on funds that remain with a firm for more than one year to be taxed at a lower rate than ordinary income. Of course, even if the tax rates on the two kinds of income are equal, the inequalities will hold. Only in the case where dividends are not taxed at the corporate level (which was formerly the case in the United Kingdom) will the ranking given above not hold.

10 See Hall and Van Reenen (2000) for details.

- The venture capital market remains dominated by activity in the United States (were consistent data available on corporate venturing and other forms of entrepreneurial finance, this disparity might not be as extreme).
- Activity in Europe and Israel has been variable, and has slumped particularly in the most recent period.
- Asian venture capital activity has grown disproportionately in recent years.

In this section, we will explore what may account for the extreme temporal variations in entrepreneurial finance we see in figures 2 and 3.

3.b.i. A Simple Framework[11]

To help understand the dynamics of the entrepreneurial finance, it is helpful to employ a simple framework. The two critical elements for understanding shifts in the amount of entrepreneurial finance provided 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 these funds. These also drive the returns that investors earn in these markets.

The supply of entrepreneurial finance is determined by the willingness of investors to provide funds to financing new ventures. The willingness of investors to commit money to venture capital funds and other forms of entrepreneurial finance, in turn, is dependent upon the expected rate of return from these investments relative to the return they expect to receive from other investments. Higher expected returns lead to a greater desire of investors to finance entrepreneurs. As the return that investors expect to earn from their investments increases — that is, as we go up the vertical axis — the amount supplied by investors grows (we move further to the right on the horizontal axis).

The number of entrepreneurial firms seeking 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 return sought by the 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 entrepreneurial finance in the economy. This is illustrated in Figure 4. The level of financing should be determined by where the two lines — the supply curve (S) and the demand curve (D) — meet. Put another way, we would expect a quantity Q of entrepreneurial finance to be raised in the economy, while the funds are expected to earn a return of R on average.

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 Labour's clarification of the "prudent man" rule of the Employee Retirement Income Security Act (ERISA) in 1979. The willingness of investors to provide capital before the clarification of ERISA policies looked like 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 US. 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.

11 The supply and demand framework for analysing entrepreneurial finance discussed here was introduced in Poterba (1989) and refined in Gompers and Lerner (1998b).

3.b.ii. 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 entrepreneurial finance.

But the quantity of finance raised by entrepreneurs and the returns it enjoys often do not adjust quickly and smoothly to the changes in supply and demand curves. We can illustrate this by comparing the entrepreneurial finance 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.

By way of contrast, in the entrepreneurial finance market the quantity of funds provided may not shift rapidly. The adjustment process is often quite slow and uneven, which 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 can be illustrated again using our 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 financing entrepreneurial ventures. Thus, the short-run curve may instead be a vertical line (SS).

This difference is illustrated Figure 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 opportunities for new ventures. 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 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 capital available may be essentially fixed. Instead of 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. The first is the structure of venture capital funds themselves. 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 accomplished. The nature of venture capital funds, however, makes these kinds of rapid adjustments much more difficult.

Consider an instance where 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 funds only raise funds every two or three years, if the endowment simply wants to increase its commitment to existing funds, they will need to wait until the next fundraising cycle occurs for these funds. In many cases, they may be unable to invest as much in the new funds as they wish.

The reluctance of venture groups to accept their 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 organisational 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 only be drawn down 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 the correction, flows into venture capital funds continued to rise, not reaching their peak until the last quarter of 1989.[12]

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

The second reason for such rigidity is the slowness with which information on performance is reported back to investors. While mutual and hedge funds holding public securities are "marked to market" on a daily basis, the delays between the inception of a new venture and the discovery of its quality is long indeed.

The information lags in entrepreneurial finance can have profound effects. For instance, when the investment environment becomes far more attractive, it can take a number of years to fully realise the fact. While investments in Internet-related securities in the mid-1990s yielded extremely high returns, it took many years for the bulk of institutional investors to realise 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 plough money into funds and new ventures.

Some of these information problems stem from the firms themselves. High potential entrepreneurial firms 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. The first of these is the

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

conservatism of the valuations. 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 limits the danger that investors will be misled into thinking that the fund is doing better than it actually is, this practice minimises the information flow about the current state of the market.[13]

This reporting practice, for instance, must lead us to be cautious in evaluating the returns depicted in Figure 3. Because relatively few firms get taken public during "cold" markets and many do during "hot" ones, there are many more dramatic write-ups in 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. Thus, the signals that venture groups receive are quite limited.

3.b.iii. Over-Reaction

Another frequently discussed pathology in the entrepreneurial finance 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 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 financing new ventures. Returns rise dramatically as a result. While the supply of capital will ultimately adjust, in the interim promising companies may not be able to attract funding. In this section, we explore two possible explanations for this phenomenon.

One possibility is that institutional investors and intermediaries may overestimate the shifts that have occurred. They may believe that there are tremendous new opportunities, and consequentially shift the supply of capital to meet that apparent demand.

This suggestion is captured in Figure 6. A positive shock to the demand for entrepreneurial finance occurs, moving the demand curve out from D_1 to D_2. Institutional investors and entrepreneurs, 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 the public markets. Examples abound where institutions 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 report. 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 are not fully anticipated.

Whatever the causes of these mis-valuations, historical illustrations are plentiful. One famous example was during the early 1980s, when 19 disk drive companies received venture capital financing. [For detailed discussions, see Sahlman and Stevenson (1985) 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 during

13 The problems with the accounting schemes for R&D persist despite the efforts of international and US. accounting standards bodies (Powell, 2003).

this period of time (sales increased from USD27 million in 1978 to USD1.3 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% 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 the public markets may also lead to over- and under-investment in entrepreneurial finance as a whole. For instance, 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 level of venture capital will have once again over-shot its target.

A second explanation for the "over-shooting" phenomenon is venture capitalists' failure to consider the costly adjustments associated with the growth of their own investment activity. The very act of growing the pool of venture capital under management may cause distractions and introduce organisational 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 in which venture groups invest their capital, which has a deleterious effect on returns. A second possibility is that growth introduces strains on the venture organisation itself.

First, consider the types of pressures that rapid growth imposes on the venture investment process. Rather than making more investments, rapidly growing venture organisations 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 scrutinise. This shift to larger investments has frequently entailed making larger capital commitments to firms up-front. This 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 groups can allow each of their partners to manage more capital while keeping the number of companies that they are responsible for down to a manageable level. But this syndication can have a number of advantages, such as helping reduce the danger of costly investment mistakes.

Another set of explanation factors relates to organisational 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 organisations 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 London-based Schroder Ventures [Lerner *et al.* (1996)]. Schroders' private equity effort began in 1985 with funds focused on British venture capital and buyout investments. Over time, however, they 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 organisation 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 organisation 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 co-operating (and sharing the capital gains) with the others. While the organisation 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 organisations. Very similar tensions have appeared in US. rapidly growing groups between general partners specialising 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 co-ordinate and oversee activities. In some cases, these tensions have led to groups splitting apart. In other cases, a key partner — often dissatisfied with his role or compensation — has departed a venture group, entailing a real disruption to the organisation.

In short, rapid growth puts severe pressures on venture capital organisations. 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 counter-productive, however, and lead to disappointing returns.

3.c. Empirical evidence

We now turn to understanding the empirical evidence on the impact of market cycles on innovation and entrepreneurship. The bulk of the studies have focused on documenting that capital constraints can impact spending on innovation: put another way, that the efficient markets view suggested in section 3.a is not borne out. After summarising this body of work in section 3.c.i, I will turn to the considerably smaller body of work that looks directly at market cycles in sections 3.c.2 and 3.c.3.

3.c.i. Studies of capital constraints on innovation and entrepreneurship

The usual way to examine the empirical relevance of the arguments that innovative investment can be disadvantaged when internal funds are not available and recourse to external capital markets required is to estimate R&D investment equations and test for the presence of "liquidity" constraints, or excess sensitivity to cash flow shocks. This approach builds on the extensive literature developed for testing ordinary investment equations for liquidity constraints (Fazzari, Hubbard, and Petersen, 1988; Arellano and Bond, 1991). It suffers from many of the same difficulties as the estimates in the investment literature, plus one additional problem that arises from the tendency of firms to smooth R&D spending over time.

The ideal experiment for identifying the effects of liquidity constraints on investment is to give firms additional cash exogenously, and observe whether they pass it on to shareholders or use it for investment and/or R&D. If they choose the first alternative, either the cost of capital to the firm has not fallen, or it has fallen but they still have no good investment opportunities. If they choose the second, then the firm must have had some unexploited investment opportunities that were not profitable using more costly external finance. A finding that investment is sensitive to cash flow shocks that are not signals of future demand increases would reject the hypothesis that the cost of external funds is the same as the cost of internal funds. However, lack of true experiments of this kind forces researchers to use econometric techniques such as instrumental variables to attempt to control for demand shocks when estimating the investment demand equation, with varying degrees of success.

The methodology for the identification of R&D investment equations is again based on a simple supply and demand heuristic, as shown in Figure 7a. The curve sloping downward to the right represents the demand for R&D investment funds and the curves sloping upward the supply of funds. Internal funds are available at a constant cost of capital until they are exhausted, at which point it becomes necessary to issue debt or equity in order to finance more investment. When the demand curve cuts the supply curve in the horizontal portion, a shock that increases cash flow (and shifts supply outward) has no effect on the level of investment. However, if the demand curve cuts the supply curve where it is upward sloping, it is possible for a shock to cash flow to shift the supply curve out in such a way as to induce a substantial increase in R&D investment. Figure 7b illustrates such a case, where the firm shifts from point A to point B in response to a cash flow shock that does not shift the demand curve.

To model these changes, two broad approaches are possible: the first is to model the function driving liquidity and R&D spending proxies for changes in financial position, such as dividend behaviour, new share issues, or new debt issues. The second is to divide firms in some way that is related to the level of cash constraints that they face (for example, dividend-paying and non-dividend paying firms), estimate separate investment equations for each group, and test whether the coefficients are equal. This latter was the method used by Fazzari, Hubbard, and Petersen (1988) in the paper that originated this literature.[14]

During the past several years, various versions of the methodologies described above have been applied to data on the R&D investment of US, UK, French, German, Irish, and Japanese firms. The firms examined are typically the largest and most important manufacturing firms in their economy. For example, Hall (1992) found a large positive elasticity between R&D and cash flow, using a very large sample of US. manufacturing firms. Similarly and using some of the same data, Himmelberg and Petersen (1994) looked at a panel of 179 US small firms in high-tech industries and found an economically large and statistically significant relationship between R&D investment and internal finance.

More recently, J. Brown *et al.* (2009) have shown that both cash flow and the issuance of public equity are very important for younger U.S. firms during the 1990-2004 period, while they have little impact on mature firm R&D investment. They focus on the high-technology sector (drugs, office and computing equipment, communications equipment, electronic components, scientific instruments, medical instruments, and software), which account for almost all of the increase in R&D during this period. A novel finding in this paper and a companion paper by J. Brown and Petersen (2009) is the increased importance of public equity issuance in financing R&D in the United States, which doubtless reflects a shift in expectations on the part of investors during this period.

Harhoff (1998) found weak but significant cash flow effects on R&D for both small and large German firms, although the results were weaker due to the smoothness of R&D and the small sample size. Combining limited survey evidence with his regression results, he concludes that R&D investment in small German firms may be constrained by the availability of finance. Bond, Harhoff, and Van Reenen (1999) find significant differences between the cash flow impacts on R&D and investment for large manufacturing firms in the United Kingdom and Germany. German firms in their sample are insensitive to cash flow shocks, whereas the investment of non-R&D-doing UK firms does respond. Cash flow helps to predict whether a UK firm does R&D, but not the level of that R&D. They interpret their findings to mean that financial constraints are important for British firms, but that those which do R&D are a self-selected group that face fewer constraints. This is consistent with the view that the desire of firms to smooth R&D over time combines with the relatively high cost of financing it to reduce R&D well below the level that would be obtained in a frictionless world.

14 See also Kaplan and Zingales (1997) for a critique of their approach, and Fazzari, Hubbard, and Petersen (2000) for a response to the critique.

Mulkay, Hall, and Mairesse (2001) perform a similar exercise using large French and US manufacturing firms, finding that cash flow impacts are much larger in the United States than in France, both for R&D and for ordinary investment. They suggest that they are due to differences in the structure of financial markets rather than the type of investment, tangible or intangible. This result is consistent with evidence reported in Hall, Mairesse, Branstetter, and Crepon (1999) for the United States, France, and Japan during an earlier time period, which basically finds that R&D and investment on the one hand, and sales and cash flow on the other, are simultaneously determined in the United States, whereas in the other countries, there is little feedback from sales and cash flows to the two investments. Using data for the United States, United Kingdom, Canada, Europe, and Japan, Bhagat and Welch (1995) found similar results for the 1985-1990 period, with stock returns predicting changes in R&D more strongly for the US and UK firms. Bougheas, Görg, and Strobl (2001) examined the effects of liquidity constraints on R&D investment using firm-level data for manufacturing firms in Ireland and also found evidence that R&D investment in these firms is financially constrained, in line with the previous studies of US and UK firms.

W. Brown (1997) argues that existing tests of the impact of capital market imperfections on innovative firms cannot distinguish between two possibilities: 1) capital markets are perfect and different factors drive the firm's different types of expenditure or 2) capital markets are imperfect and different types of expenditure react differently to a common factor (shocks to the supply of internal finance). He then compares the sensitivity of investment to cash flow for innovative and non-innovative firms in the United Kingdom. The results support the hypothesis that capital markets are imperfect, finding that the investment of innovative firms is more sensitive to cash flow.

The conclusions from this body of empirical work are several: first, there is solid evidence that debt is a disfavoured source of finance for R&D investment; second, the "Anglo-Saxon" economies, with their thick and highly developed stock markets and relatively transparent ownership structures, typically exhibit more sensitivity and responsiveness of R&D to cash flow than continental economies; third, and much more speculatively, this greater responsiveness may arise because they are financially constrained, in the sense that they view external sources of finance as much more costly than internal, and therefore require a considerably higher rate of return to investments done on the margin when they are tapping these sources. However, it is perhaps equally likely that this responsiveness occurs because firms are more sensitive to demand signals in thick financial equity markets; a definitive explanation of the "excess sensitivity" result awaits further research [15] In addition to these results, the evidence from Germany and some other countries suggests that small firms are more likely to face this difficulty than large established firms (not surprisingly, if the source of the problem is a "lemons" premium).

From a policy perspective, these results point to another reason why it may be socially beneficial to offer tax incentives to companies, especially to small and new firms, in order to reduce the cost of capital they face for R&D investment. Many governments, including not only those in the developed world (*e.g.*, the United States and the United Kingdom), but also in the developing world (*e. g.,* Chile, Brazil, and Argentina) currently have such programmes. Such a policy approach simply observes that the cost of capital is relatively high for R&D and tries to close the gap via a tax subsidy.

The literature on capital constraints and entrepreneurship is less developed, but also controversial. Generally, economists have taken two approaches to understanding these issues: focusing on comparisons across regions and comparisons between different individuals in the same region.

15 It is also true that much of the literature here has tended to downplay the role of measurement error in drawing conclusions from the results. Measurement error in Tobin's q, cash flow, or output is likely to be sizable and will ensure that all variables will enter any specification of the R&D investment equation significantly, regardless of whether they truly belong or not. Instrumental variables estimation is a partial solution, but only if all the errors are serially uncorrelated, which is unlikely.

To illustrate the first approach, a wide variety of studies in the law and finance literature have related aspects of the legal environment in various nations to the ability of firms to raise capital. For instance, Fisman and Love (2003) explore the use of trade credit. They show that industries that rely more on trade credit financing in the United States (and presumably are more conducive to this form of financing everywhere) grow faster in countries with weaker financial institutions, suggesting that trade credit substitutes for other forms of financing. But not all firms benefit from this: this pattern is driven by growth in established firms, suggesting that entrepreneurs struggle to get access to trade credit.

Another example is Berkowitz and White's (2004) study of the impact of individual bankruptcy protection. They show that in US. states with stronger personal bankruptcy protection, entrepreneurs are less likely to get credit. Presumably, banks and other lenders — who frequently demand a personal guarantee, are less willing to lend to entrepreneurs in places where their ability to recover funds in case of failure is severely limited.

A final example is Black and Strahan's (2002) analysis of deregulation of banks across U.S. states. They show that the rate of new business incorporations increases following the lifting of limits on branch banking. Moreover, the negative impact of having a highly concentrated banking system on entrepreneurship seems to diminish after deregulations. Taken collectively, these three studies — and the preponderance of other work in the spirit of regional comparisons — suggest the entrepreneurs are indeed limited by financial constraints.

An alternative approach has been to compare different individuals. Evans and Jovanovic (1984) initiated this line of inquiry with a simple model that hypothesised that entrepreneurs' ability to borrow would be limited by their personal wealth. Thus, richer would-be entrepreneurs should be able to access more capital and do better. Using US Census data, they find evidence consistent with this hypothesis, suggesting that capital constraints do limit entry into entrepreneurship.

A natural concern with this approach is that wealth may be correlated with either attributes: for instance, well-off new entrepreneurs may have benefited from excellent schooling and have more extensive social networks. One way that economists have sought to get around this identification issue is by using bequests: the death of a wealthy relative can be seen as an exogenous event which affects the entrepreneur's wealth. Holtz-Eakin and co-authors (1994) show that individuals who receive large bequests are more likely to remain entrepreneurs and their enterprises grow more quickly. Again, though, we might worry that these bequests are not totally unanticipated and are likely to be correlated with other attributes.

Further rising concerns about the impact of financial constraints are suggested by the influential paper by Hurst and Lusardi (2004). Again using U.S. Census data, the authors look at the relationship between wealth and the probability of becoming an entrepreneur. They show that the relationship between an entrepreneurial transition and household wealth is essentially flat for the bottom three wealth quartiles, and that the observed relationship is primarily driven by the wealthiest five% of households. Moreover, they show that in regions where real estate prices have appreciated more dramatically, individuals are no more likely to begin a business than elsewhere.

These findings at the individual level suggest a weaker relationship between financial constraints and entrepreneurial activity. But it is worth noting that many of these studies aggregate different types of entrepreneurship together, including both what Schoar (2009) terms "subsistence" and "transformational" entrepreneurs. Thus, the interpretation of these results must be cautious.

3.c.ii. Analyses of cycles and their impact on innovative entrepreneurship

We have already discussed how in many instances the levels of funding during peak periods appear to "overshoot" the desired levels. Empirical studies have tried to document this issue, though the analyses are frequently challenging.

At the most basic level, the presence of cycles in the activity and volume of entrepreneurial finance activity have been well documented. Variations in the volume of and valuations in venture financing have been documented by, among others, Gompers and Lerner (1998, 1999) and Kaplan and Schoar (2005). This literature suggests that venture markets are intensely cyclical, with the market peaks correlated with periods of intense public market activity and favourable economic conditions. Typically, venture funds investing in fallow appear to earn attractive returns. These returns attract other investors, who commit to funds. As discussed above, these additional funds drive up valuations and drive down returns. Whether caused by the presence of misleading public market signals or the over-optimism on the part of the venture capitalists, funds appear to be deployed much less effectively during these boom periods.

These patterns are not unique to venture capital, but also appear elsewhere in entrepreneurial finance. The cyclicality in the activity of and valuations in the market for initial public offerings of common stock have been shown by, among others, Lerner (1994), Kim and Ritter (1999), and Lowry (2003).[16] Angel activity is less well-documented, but would likely display the same pattern [17]

The impact of these cycles on the innovations generated by entrepreneurs, however, is much less well documented. Anecdotally, all too often these periods find venture capitalists funding firms that are too similar to one another.[18] The consequences of these excessive duplications 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 alleging intellectual property and misappropriation of ideas across firms, and the sudden termination of funding for many of these concerns.

The boom of 1998-2000 provides many illustrations. Funding during these years was concentrated in two areas: Internet and telecommunication investments, which, for instance, accounted for 39% and 17% of all venture disbursements in 1999. Once again, considerable sums were devoted to supporting highly similar firms — *e.g.*, the nine dueling Internet pet food suppliers — or else efforts that seemed fundamentally uneconomical and doomed to failure, such as companies which undertook the extremely

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16 There is also substantial literature showing variations in corporate R&D spending over the business cycles. For instance, Goullec and Ioannidis (1997) show that GDP does seem to play a significant role in shaping R&D spending in both the long and short run. The long-run elasticity of GDP ranges from 1.7 to 2 depending on the panel. While this work is interesting, it is beyond the scope of this paper.

17 A natural question is whether these patents in entrepreneurial finance are also reflected in the amount of entrepreneurship. The challenge empirically is distinguishing between "transformational" entrepreneurship, which typically relies heavily on external finance, and "substance" entrepreneurs. (For a discussion of this distinction, see Schoar (2009).) For instance, a downturn may see an explosion of laid-off corporate employees setting up shop as self-employed consultants, while the number of ambitious start-ups declines sharply. For an analysis that illustrates these difficulties, see Koellinger and Thurik (2009). One of the few exceptions is Heger (2004), who uses data from the Mannheim Innovation Panel (MIP) to examine the cyclical pattern of innovation by small and large firms. The analysis suggests that business cycle indicators matter more for small firms when considering whether to begin innovating.

18 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 too similar to each other. For a review of these works, see Davenow and Welch (1996).

capital-intensive process of building a second cable network in residential communities. Meanwhile, many apparently promising areas — *e.g.*, 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.

While there is little analysis of this question in published literature, these suggestive accounts can be 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 analyse annual data for 20 manufacturing industries between 1965 and 1992. The dependent variable is U.S. patents issued to U.S. inventors by industry and date of application. The 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 Kortum and Lerner paper, we show that the patterns appear to hold when we use other measures of innovation). Similarly, we are required to aggregate venture funding and patents into a 20-industry scheme that is used by the NSF to measure R&D spending. Finally, our analysis must exclude the greatest boom period of all, the 1998-2000 surge (patent applications can only be observed with a considerable lag).

Table 1 presents our 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 we estimate the impact of venture capital on innovation separately for those periods that had the greater venture capital investments (defined here as the top 1% of industry-year observations). As the table reports, the impact of venture capital on innovation is some 15% 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 we 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.

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 we can see "overshooting" by investors, so can we see prolonged "undershooting."

One sobering example was the 1970s. The late 1960s had seen record fundraising, both by independent venture groups and Small Business Investment Companies (SBICs), federally subsidised 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 licences appeared to emphasise 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.

Figure 8 depicts one consequence of the period of this reaction : 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 USD1.2 billion (in today's dollars) in 1968-69 to just USD201 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 conceptualised or were engaged in doomed battles with entrenched incumbents such as IBM. But many other firms seeking to commercialise 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 commercialise their ideas. Thus, the real worry is the stickiness in the venture market will lead to prolonged periods where investors will be unwilling to fund entrepreneurs, despite the promise of the ideas they are developing.

4. The impact of the current global crisis on this relationship

In this final section, I turn to conclusions that can be drawn from this analysis. Four implications seem particularly striking. I also raise a variety of more speculative suggestions regarding appropriate public policies.

4.a. What we definitely know

As we have highlighted in this essay, several clear patterns characterize the impact of the current global crisis on the financing of high-potential entrepreneurial firms:

1. The current global crisis is having a dramatic effect on the financing of innovation. Venture firms and other investors are suffering from the inability to exit investments or raise follow-on capital and many institutional and individual investors are raising questions about the prospect of returns going forward. Meanwhile entrepreneurs running high-potential firms worry about the inability to raise capital and the difficulty of gaining traction in the product market.

2. This is not the first such crisis in entrepreneurial finance. The venture market has tended to be highly cyclical, with periods of boom and bust. During the hot markets, there is frequently "over-shooting" as too much capital is contributed to the industry; during down periods, the opposite dynamic can take place. The market for financing high-potential entrepreneurial firms appears far from an efficient one.

3. These patterns reflect the fact that financial constraints appear to limit high potential entrepreneurs. A substantial body of literature suggests that spending on innovative activities, particularly by smaller firms, is limited by capital constraints. The evidence regarding capital constraints and entrepreneurship is weaker, but may reflect the tendency of many studies (due to data limitations) to aggregate together very different types of entrepreneurial activity.

4. These funding cycles are serious because of the importance of high potential ventures for innovation. While relating firm types to innovation is inherently difficult, the preponderance of evidence suggests that young, high-potential firms are likely to play an important role in boosting innovation. Young firms appear not only to be important generators of large numbers of innovations, but also particularly important in developing radical breakthroughs. Economists have hypothesised a variety of reasons why these patterns may hold, from their incentive schemes to their organisation structure.

4.b. More speculative thoughts

Government officials and policy advisors are naturally concerned about spurring innovation. Encouraging financing for entrepreneurs and venture capital 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 we have highlighted, entrepreneurial finance is intensely cyclic, and the impact of venture capital on innovation is likely to be different within this cycle. Yet government programmes 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. Rather it is in periods such as today where such efforts should be concentrated.

This type of behaviour reflects the manner in which such policy initiatives are frequently evaluated and rewarded. Far too often, the appearance of a successful programme is far more important than actual success in spurring innovation. For instance, many "public venture capital" programmes prepare glossy brochures full of "success stories" about particular firms. The prospect of such recognition may lead a programme 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 quite modest). To cite one example, the Advanced Technology Programme launched major efforts to fund genomics and Internet tools companies during periods when venture funding was flooding into these sectors (Gompers and Lerner, 1999).

By way of 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 US Small Business Innovation Research programme provides another contrasting example. Decisions as to whether to finance firms are made not by centralised bodies, but rather devolved in many agencies to programme managers who are seeking to address very specific technical needs (*e.g.*, an Air Force research administrator who is seeking to encourage the development of new composites). As a result, many "off beat" technologies that are not of interest to traditional venture investors have been funded through this programme.

A far more successful approach would be to address the gaps in the venture financing process. As noted above, venture investments tend to be very focused into a few areas of technology that are perceived to have great potential. Increases in venture fundraising — 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. Policy makers may wish to respond to these industries conditions by *i)* focusing on technologies which are not currently popular among venture investors and *ii)* providing follow-on capital to firms already funded by venture capitalists during periods when venture inflows are falling.

More generally, the greatest assistance to the financiers of entrepreneurial firms may be provided by government programmes that seek to enhance the demand for these funds, rather than the supply of capital. Examples would include efforts to facilitate the commercialisation 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 (*e.g.*, 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, the most effective programmes and policies aimed at spurring venture capital and entrepreneurial innovation are those which lay the foundations for effective private investment. Our 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 and other forms of entrepreneurial finance over the past two decades, 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 periods when the market is already active.

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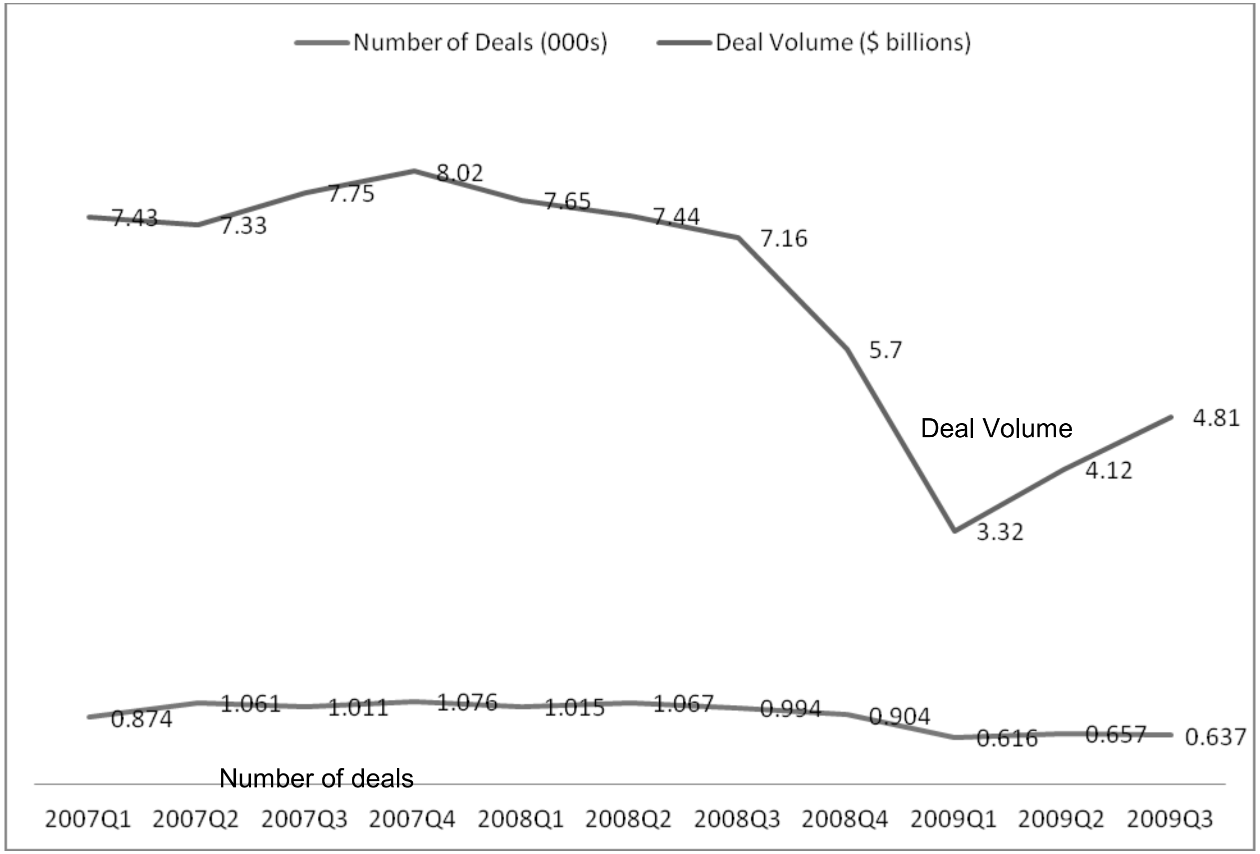
Table 1. Implied impact of venture capital on innovation, based on the linear patent production function estimated by Kortum and Lerner (2000).

	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

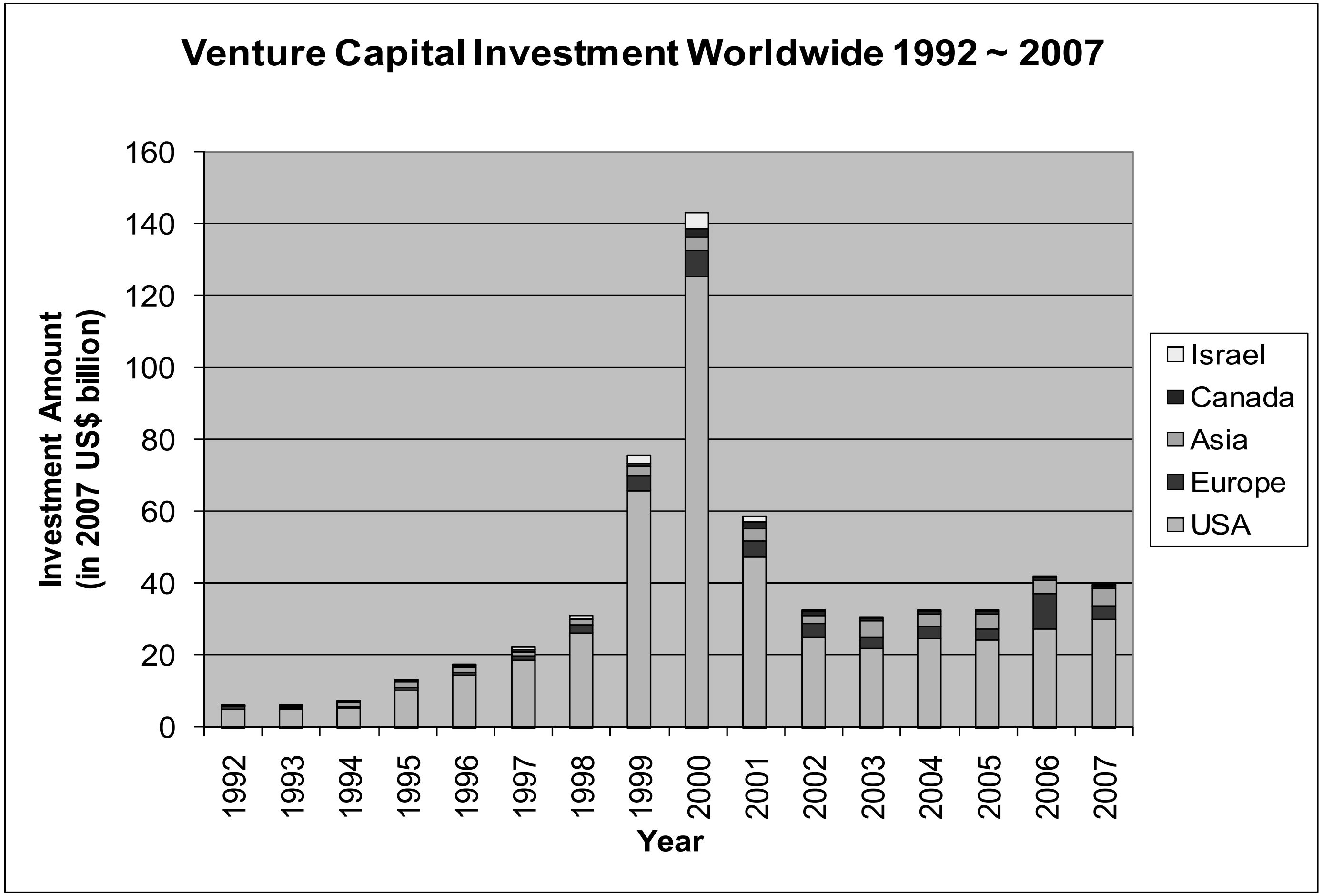
Note : The first row presents implied impact of venture financing on innovation for all manufacturing industries and years between 1965 and 1992 except where the levels of venture inflows are in the top 1%. The second row presents the implied coefficient during the industries and years where inflows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

Figure 1: US venture capital activity in recent quarters



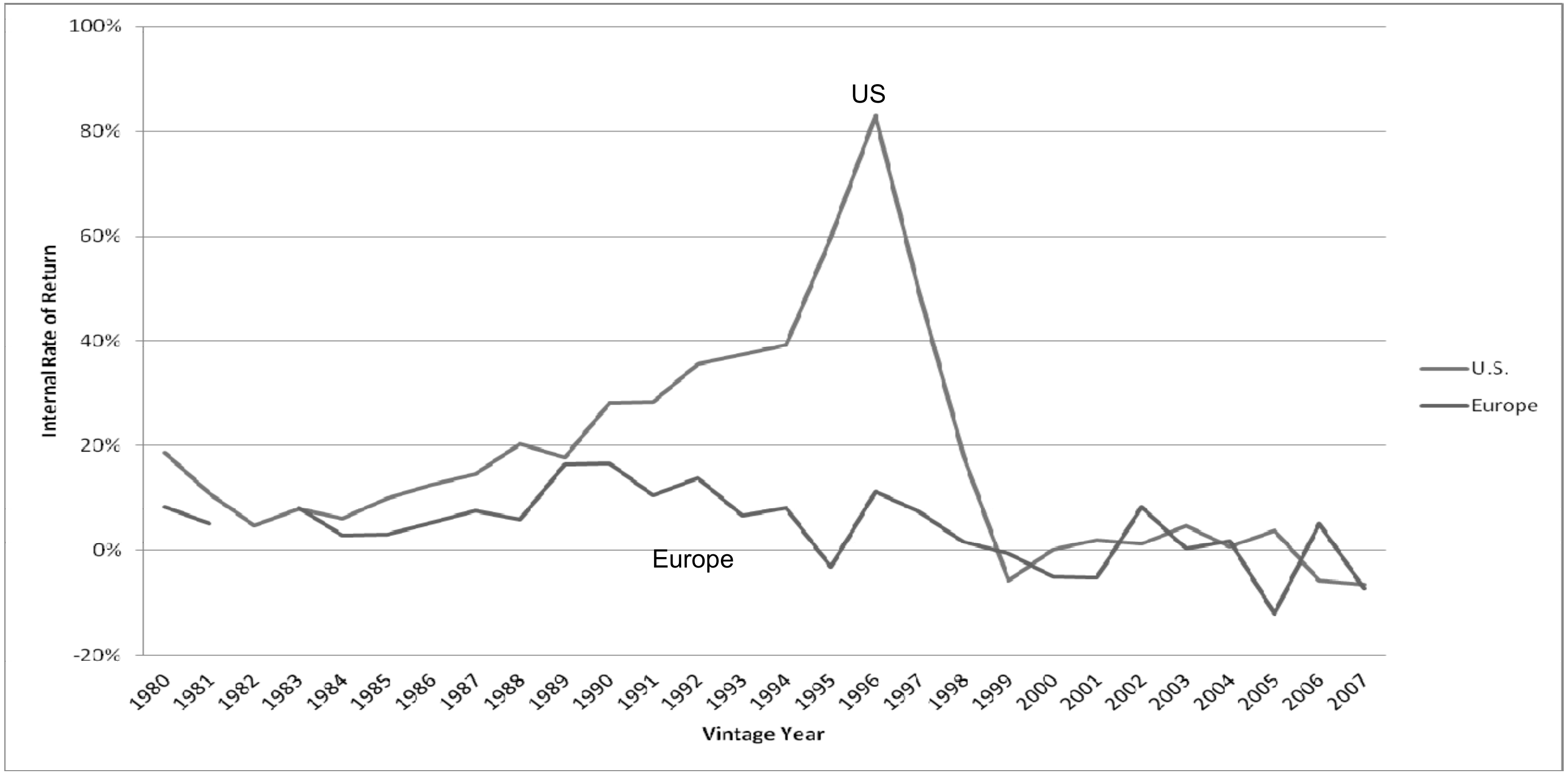
Source: The data are from the website of the National Venture Capital Association (http://www.nvca.org; accessed October 20, 2009).

Figure 2: Venture capital investment in recent years world-wide



Source: Compiled from various publications and web sites of the Canadian, European, Israeli, and US (National) venture capital associations, as well as those of the Asian Venture Capital Journal. In some nations where venture capital investments are not clearly delineated, I employ seed and start-up investments.

Figure 3: Returns to US and European venture capital funds, by vintage year, 1980-2007



Source: based on data from Thomson VentureXpert

Figure 4: Steady-state level of venture capital

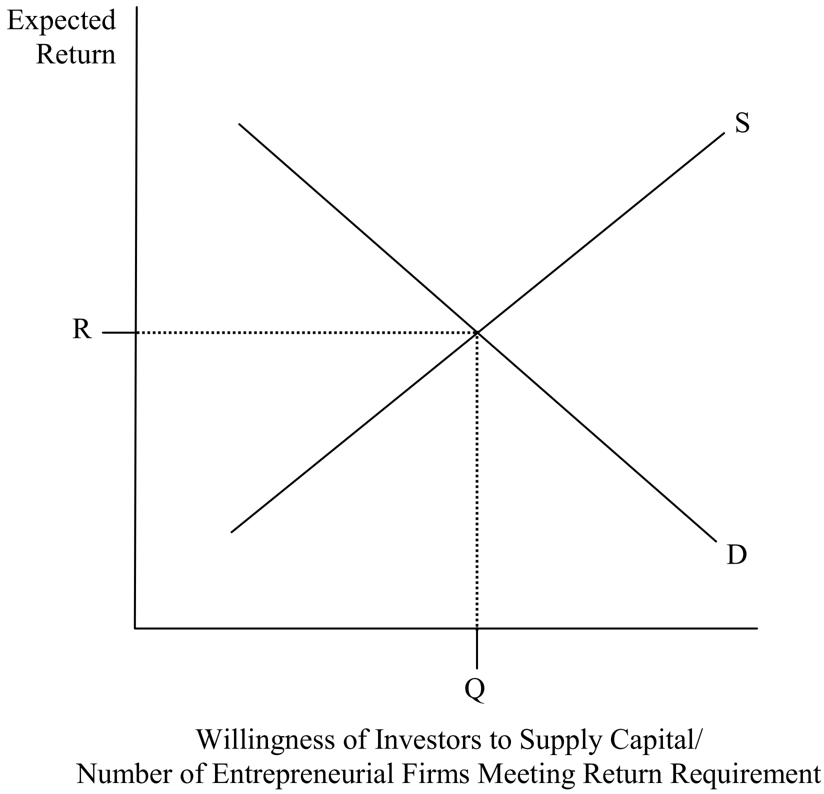


Figure 5: Impact on quantity of a demand shock

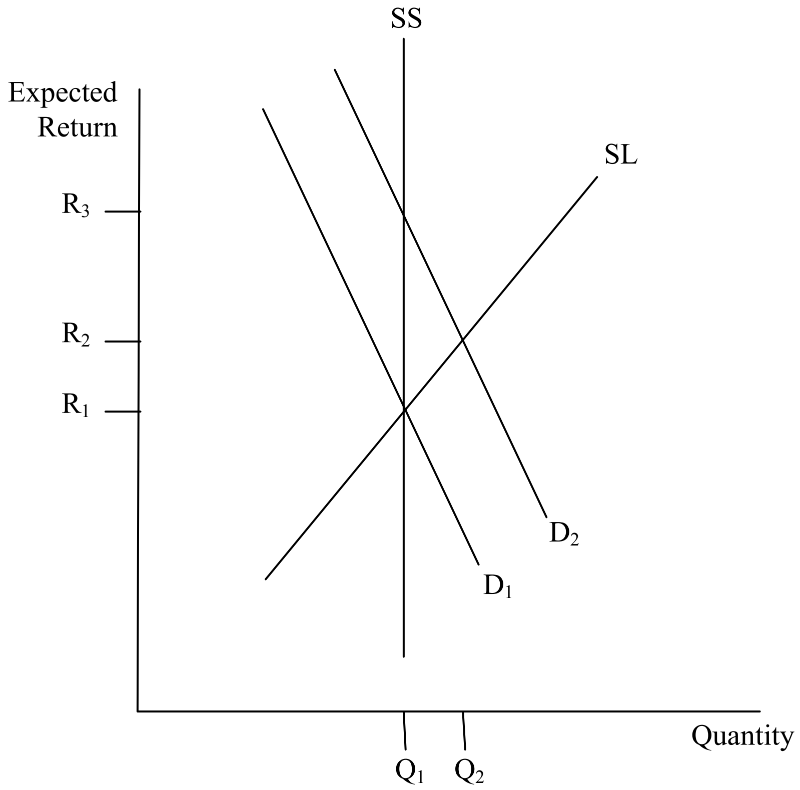


Figure 6: misleading public market signals

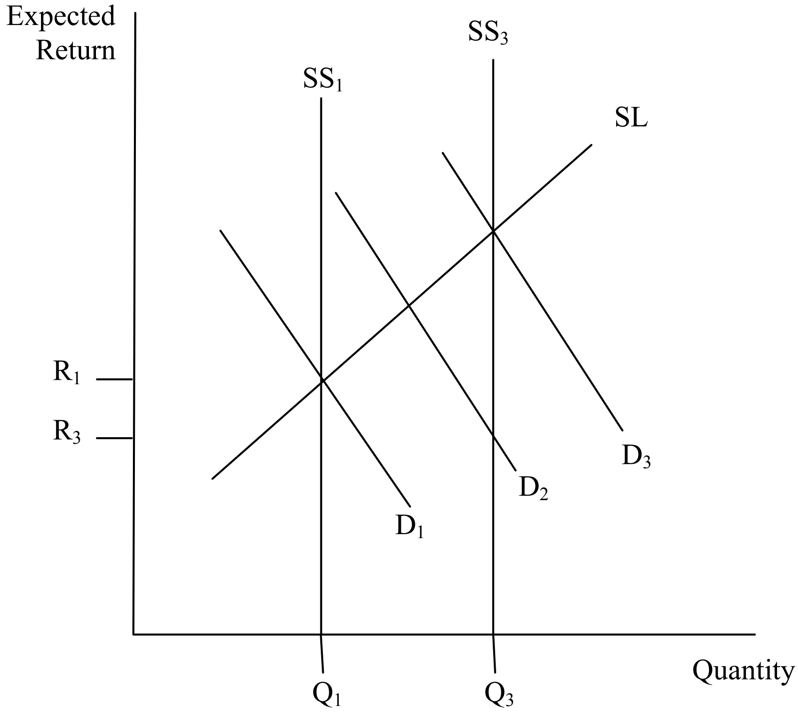


Figure 7a: Unconstrained firm

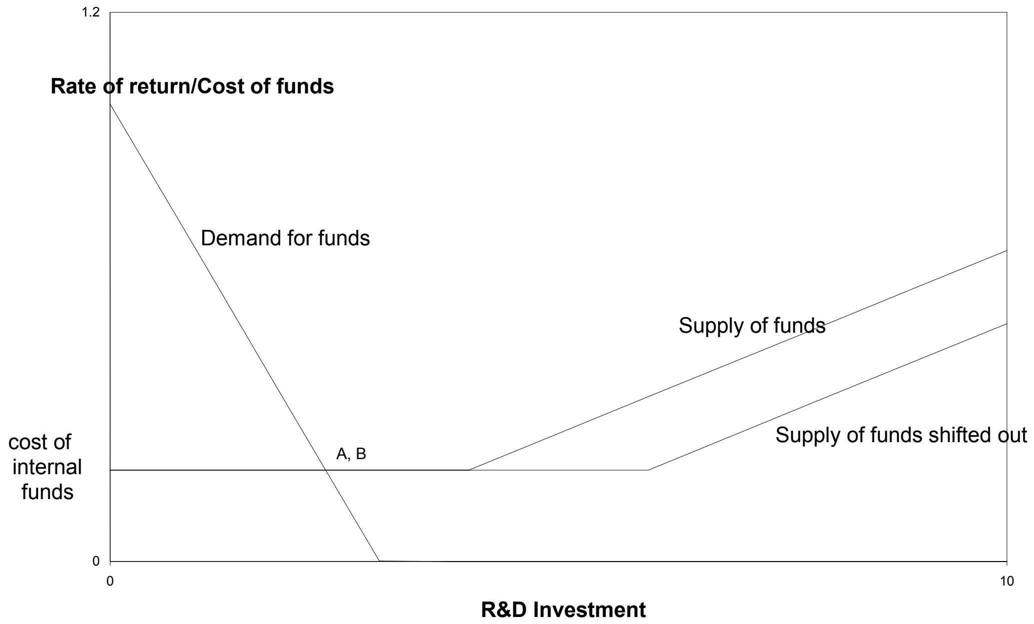


Figure 7b: Constrained firm

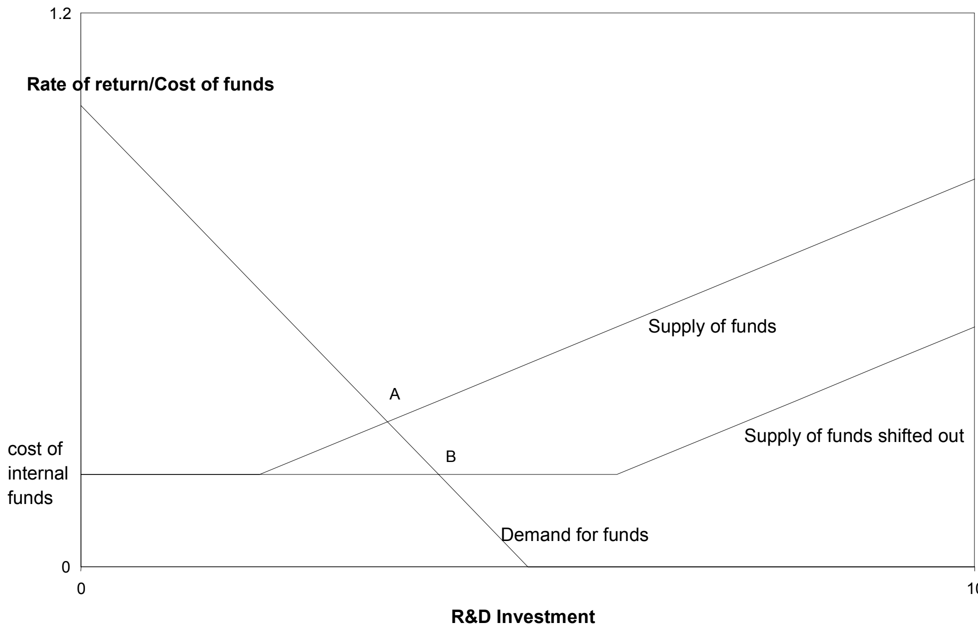
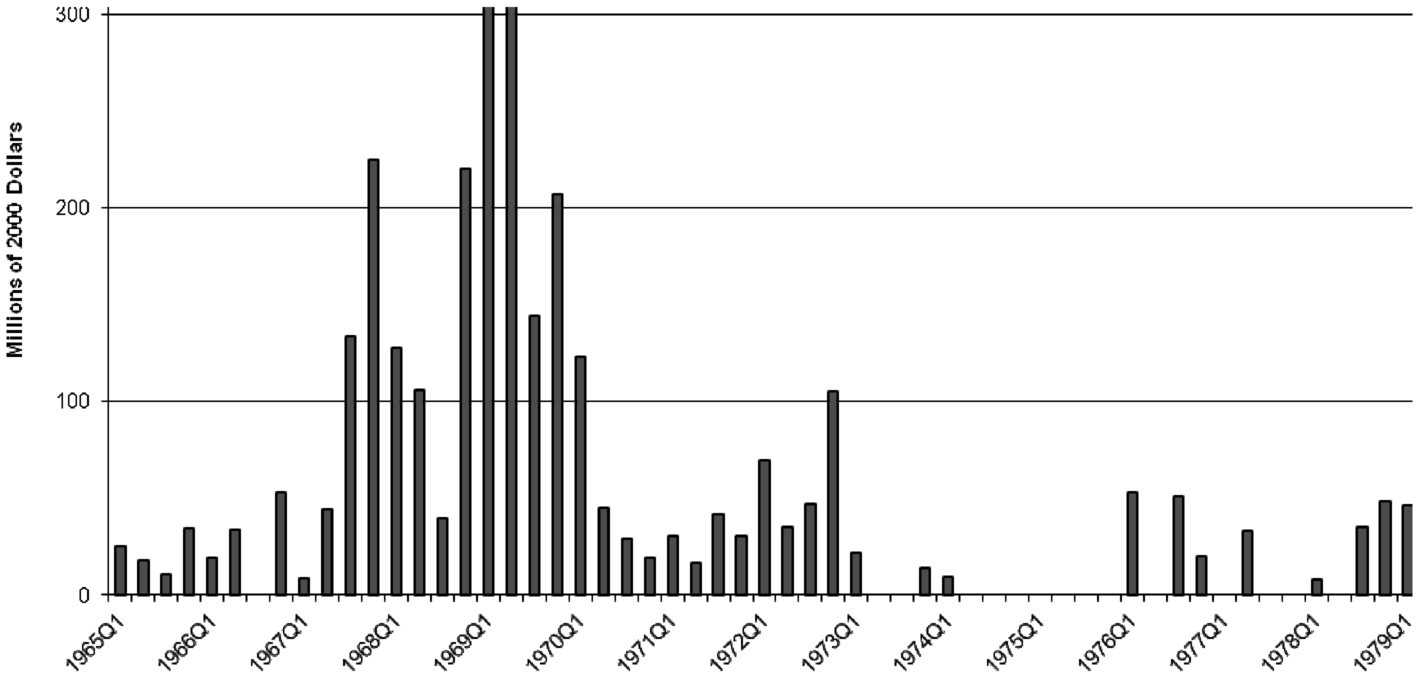


Figure 8: Initial public offerings and seasoned equity offerings by computer and computer-related firms, by quarter, 1965-1979



Source: compiled from information from Investment Dealers' Digest, the Securities Data Company database, and other sources.