

Small business,  
innovation, and public  
policy in the  
information  
technology indus...



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New firms have played a major role in fomenting innovation in information technology. A recent study by Greenwood and Jovanovic [1999] provide one dramatic illustration of these trends. These authors show that a group of “IT upstarts” firms specializing in computer and communications technologies that went public after 1968 now account for over 4% of the total U. S. equity market capitalization. While some of this growth has come at the expense of incumbent information technology firms, the new market value and technological spillovers created by these new businesses appear to be substantial.

The role of new firms in the information technology industries has rekindled interest in the relationship between firm characteristics and innovation. Are small businesses more innovative in general? Are high-technology start-ups particularly important? If the answer to either of these questions is yes, how should policymakers seek to encourage these firms? The relationship between innovation and firm characteristics has been one of the most researched topics in the empirical industrial organization literature.

To summarize these discussions and draw some implications for policymakers in a few pages is thus a daunting challenge! Consequently, this essay takes a quite selective approach to these issues. First, I very briefly summarize the academic literature on the relationship between firm size and innovation. This work suggests that there appears to be a very weak relationship between firm size, the tendency to undertake R&D, and the effectiveness of research spending. Small businesses, in aggregate, do not appear to be particularly research-intensive or innovative.

I then turn to examining one subset of small businesses that do appear to excel at innovation: venture capital-backed start-ups. I highlight some of the venture-backed firms' contributions. I also discuss why the success of such firms is not accidental. In particular, I highlight the key problems that the financing of small innovative companies pose, as well as some of the key mechanisms that venture investors employ to guide the innovation process. It is not surprising, then, that venture capital investments are concentrated in information technology industries, and that they appear to pur innovation. Finally, I consider one set of policy issues related to small firms and innovation. In particular, I discuss some recent changes in the intellectual property protection system that appear to favor larger firms. I then argue that this may be an area that would reward increased attention by policy-makers interested in helping innovative small businesses in information technology and other high-technology industries.

### 1. Small Business and Innovation

A substantial but largely inconclusive literature examines the relationship between firm size and innovation.

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. 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]. Much of the work in this literature has sought to relate measures of innovative discoveries??? whether R 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). 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%.

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 the pioneering case study-based research of Jewkes, Sawers, and Stillerman [1958]. Acs and Audretsch [1988] examined this question more systematically. 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.

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. These patterns are also predicted in several models of technological competition, many of which were reviewed in Reinganum [1989], as well in several analyses in the organizational behavior literature [several were discussed in Henderson, 1993]. The 1990s have seen several dramatic illustrations of these patterns.

Two potentially revolutionary areas of technological innovation???

biotechnology and the Internet??? were pioneered by smaller entrants.

Neither established drug companies nor mainframe computer manufacturers were pioneers in developing these technologies. By and large, small firms did not invent the key genetic engineering techniques or Internet protocols.

Rather, the bulk of the enabling technologies were developed with Federal funds at academic institutions and research laboratories. It was the small entrants, however, who were the first to seize upon the commercial

opportunities. 2. Venture Capital and Innovation One set of small firms, however, appear to have had a disproportionate effect on innovation: those backed by venture capitalists. Venture capital can be defined as equity or equity-linked investments in young, privately held companies, where the investor is a financial intermediary is typically actively as a director, advisor or even manager of the firm. ) While venture capitalists fund only a few hundred of the nearly one million businesses begun in the United States each year, these firms have a disproportionate impact on technological innovation. This claim is supported by a variety of evidence. One measure, while crude, is provided by the firms which “graduate” to the public marketplace.

In the past two decades, about one-third of the companies going public (weighted by value) have been backed by venture investors. A second way to assess these claims is to examine which firms have been funded. Venture capitalists, while contributing a relatively modest share of the total financing, provided critical early capital and guidance to many of the new firms in such emerging industries as biotechnology, computer networking, and the

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Internet. In some cases, these new firms??? utilizing the capital, expertise, and contacts provided by their venture capital investors??? established themselves as market leaders.

In other instances, they were acquired by larger corporations, or entered into licensing arrangements with such concerns. Consider, for instance, the biotechnology industry. Venture capitalists provided only a small fraction of the external financing raised in the industry, and only 450 out of 1500 firms have received venture financing through 1995. These venture-backed firms, however, accounted for over 85% of the patents awarded and drugs approved for marketing. Similarly, venture capitalists have aggressively backed firms in information technology industries, which accounted for 60% of all venture disbursements in 1998.

These have included many of the most successful firms in the industry, including Amazon. com, Cisco Systems, Microsoft, Intel, and Yahoo. A final way to assess the impact of the venture industry is to consider the impact of venture backed firms. Survey results suggest that these investments have powerful impacts. For instance, a mid-1996 survey by the venture organization Kleiner, Perkins, Caufield, and Byers found that the firms that the partnership had financed since its inception in 1971 had created 131, 000 jobs, generated \$44 billion in annual revenues, and had \$84 billion in market capitalization [Peltz, 1996].

While Kleiner, Perkins is one of the most successful venture capital groups, the results are suggestive of the impact of the industry. More systematically, Kortum and Lerner [1998] examining the influence of venture capital on

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patented inventions in the United States across twenty industries over three decades. They address concerns about causality in several ways, including exploiting a 1979 policy shift that spurred venture capital fundraising. They find that the amount of venture capital activity in an industry significantly increases its rate of patenting.

While the ratio of venture capital to R&D has averaged less than 3% in recent years, the estimates suggest that venture capital accounts for about 15% of industrial innovations. They address concerns that these results are an artifact of the use of patent counts by demonstrating similar patterns when other measures of innovation are used in a sample of 530 venture-backed and non-venture-backed firms. Lending particular relevance to an examination of these firms is the tremendous boom in the U. S. venture capital industry in recent years.

The pool of venture partnerships has grown ten-fold, from under \$4 billion in 1978 to about \$75 billion at the end of 1998. Venture capital's recent growth has outstripped that of almost every class of financial product. It is worth underscoring that the tremendous success of venture-backed firms has not happened by accident. The interactions between venture capitalists and the entrepreneurs that they finance are often complex. They can be understood, however, as a response to the challenges that the financing of emerging growth companies pose.

Entrepreneurs rarely have the capital to see their ideas to fruition and must rely on outside financiers. Meanwhile, those who control capital??? for instance, pension fund trustees and university overseers??? are unlikely to

have the time or expertise to invest directly in young or restructuring firms. Some entrepreneurs might turn to other financing sources, such as bank loans or the issuance of public stock, to meet their needs. But because of four key factors, some of the most potentially profitable and exciting firms would be unable to access financing if venture capital did not exist.

The first factor, uncertainty, is a measure of the array of potential outcomes for a company or project. The wider the dispersion of potential outcomes, the greater the uncertainty. By their very nature, young companies are associated with significant levels of uncertainty. Uncertainty surrounds whether the research program or new product will succeed. The response of firm's rivals may also be uncertain. High uncertainty means that investors and entrepreneurs cannot confidently predict what the company will look like in the future.

Uncertainty affects the willingness of investors to contribute capital, the desire of suppliers to extend credit, and the decisions of a firm's managers. If managers are averse to taking risks, it may be difficult to induce them to make the right decisions. Conversely, if entrepreneurs are overoptimistic, then investors want to curtail various actions. Uncertainty also affects the timing of investment. Should an investor contribute all the capital at the beginning, or should he stage the investment through time? Investors need to know how information-gathering activities can address these concerns and when they should be undertaken.

The second factor, asymmetric information (or information disparities), is distinct from uncertainty. Because of his day-to-day involvement with the



firm, an entrepreneur knows more about his company's prospects than investors, suppliers, or strategic partners. Various problems develop in settings where asymmetric information is prevalent. For instance, the entrepreneur may take detrimental actions that investors cannot observe: perhaps undertaking a riskier strategy than initially suggested or not working as hard as the investor expects.

The entrepreneur might also invest in projects that build up his reputation at the investors' expense. Asymmetric information can also lead to selection problems. The entrepreneur may exploit the fact that he knows more about the project or his abilities than investors do. Investors may find it difficult to distinguish between competent entrepreneurs and incompetent ones.

Without the ability to screen out unacceptable projects and entrepreneurs, investors are unable to make efficient and appropriate decisions. The third factor affecting a firm's corporate and financial strategy is the nature of its assets.

Firms that have tangible assets??? e. g. , machines, buildings, land, or physical inventory??? may find financing easier to obtain or may be able to obtain more favorable terms. The ability to abscond with the firm's source of value is more difficult when it relies on physical assets. When the most important assets are intangible, such as trade secrets, raising outside financing from traditional sources may be more challenging. Market conditions also play a key role in determining the difficulty of financing firms. Both the capital and product markets may be subject to substantial variations.

The supply of capital from public investors and the price at which this capital is available may vary dramatically. These changes may be a response to regulatory edicts or shifts in investors' perceptions of future profitability. Similarly, the nature of product markets may vary dramatically, whether due to shifts in the intensity of competition with rivals or in the nature of the customers. If there is exceedingly intense competition or a great deal of uncertainty about the size of the potential market, firms may find it very difficult to raise capital from traditional sources.

Venture capitalists have a variety of mechanisms at their disposal to address these changing factors. They will invest in stages, often at increasing valuations. Each refinancing is tied to a re-evaluation of the company and its prospects. In these financings, they will employ complex financing mechanisms, often hybrid securities like convertible preferred equity or convertible debt. These financial structures can potentially screen out overconfident or under-qualified entrepreneurs and reduce the venture capitalists' risks.

They will also shift the mixture of investors from whom a firm acquires capital. Each source??? private equity investors, corporations, and the public markets??? may be appropriate for a firm at different points in its life.

Venture capitalists provide not only introductions to these other sources of capital but certification??? a "stamp of approval" that addresses the concerns of other investors. Finally, once the investment is made, they monitor and work with the entrepreneurs to ensure that the right operational and strategic decisions are made and implemented. 3.

Innovation, Small Business, and Public Policy If small firms??? or even some subset of small firms??? are playing an important role in the innovation process, one policy goal should be to address threats to their future development. This is particularly true of threats that have been created by misguided government policies, however good the intentions of their designers. The area that I believe deserves particular attention relates to the key mechanism for protecting intellectual property, namely patents. The U. S. patent system has undergone a profound shift over the past fifteen years.

The strength of patent protection has been dramatically bolstered, and both large and small firms are devoting considerably more effort to seeking patent protection and defending their patents in the courts. Many in the patent community??? U. S. Patent and Trademark Office officials, the patent bar, and corporate patent staff??? have welcomed these changes. But viewed more broadly, the reforms of the patent system and the consequent growth of patent litigation have created a substantial “ innovation tax” that afflicts some of America’s most important and creative small firms.

Almost all formal disputes involving issued patents are tried in the Federal judicial system. The initial litigation must be undertaken in a district court. Prior to 1982, appeals of patent cases were heard in the appellate courts of the various circuits. These differed considerably in their interpretation of patent law. Because few appeals of patent cases were heard by the Supreme Court, substantial differences persisted, leading to widespread “ forum shopping” by litigants. In 1982, the U. S.

Congress established a centralized appellate court for patent cases, the Court of Appeals for the Federal Circuit (CAFC). As Robert Merges [1992] observes, While the CAFC was ostensibly formed strictly to unify patent doctrine, it was no doubt hoped by some (and expected by others) that the new court would make subtle alterations in the doctrinal fabric, with an eye to enhancing the patent system. To judge by results, that is exactly what happened. The CAFC's rulings have been more " pro-patent" than the previous courts.

For instance, the circuit courts had affirmed 62% of district court findings of patent infringement in the three decades prior to the creation of the CAFC, while the CAFC in its first eight years affirmed 90% of such decisions [Koenig, 1980; Harmon, 1991]. The strengthening of patent law has not gone unnoticed by corporations. Over the past decade, patents awarded to U. S. corporations have increased by 50%. Furthermore, the willingness of firms to litigate patents has increased considerably. The number of patent suits instituted in the Federal courts has increased from 795 in 1981 to 1553 in 1993; adversarial proceedings within the U.

S. Patent and Trademark Office have increased from 246 in 1980 to 684 in 1992 [Administrative Office, various years; U. S. Department of Commerce, various years]. My recent analysis of litigation by firms based in Middlesex County, Massachusetts suggests that six intellectual property-related suits are filed for every one hundred patent awards to corporations. These suits lead to significant expenditures by firms. Based on historical costs, I estimate that patent litigation begun in 1991 will lead to total legal expenditures (in 1991 dollars) of over \$1 billion, a substantial amount relative to the \$3.  
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billion spent by U. S. firms on basic research in 1991. [These findings are summarized in Lerner, 1995. ] Litigation also leads to substantial indirect costs. The discovery process is likely to require the alleged infringer to produce extensive documentation, time-consuming depositions from employees, and may generate unfavorable publicity. Its officers and directors may also be held individually liable. As firms have realized the value of their patent positions, they have begun reviewing their stockpiles of issued patents.

Several companies, including Texas Instruments, Intel, Wang Laboratories, and Digital Equipment, have established groups that approach rivals to demand royalties on old patent awards. In many cases, they have been successful in extracting license agreements and/or past royalties. For instance, Texas Instruments is estimated to have netted \$257 million in 1991 from patent licenses and settlements resulting from their general counsel's aggressive enforcement policy [Rosen, 1992]. Particularly striking, practitioner accounts suggest, has been the growth of litigation—and threats of litigation—between large and small firms.

This trend is disturbing. While litigation is clearly a necessary mechanism to defend property rights, the proliferation of such suits may be leading to transfers of financial resources from some of the youngest and most innovative firms to more established, better capitalized concerns. Even if the target firm feels that it does not infringe, it may choose to settle rather than fight. It either may be unable to raise the capital to finance a protracted court battle, or else may believe that the publicity associated with the litigation will depress the valuation of its equity.

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In addition, these small firms may reduce or alter their investment in R&D. For instance, a 1990 survey of 376 firms found that the time and expense of intellectual property litigation was a major factor in the decision to pursue an innovation for almost twice as many firms with under 500 employees than for larger businesses [Koen, 1990]. These claims are also supported by my study [1995] of the patenting behavior of new biotechnology firms that have different litigation costs.

I showed that firms with high litigation costs are less likely to patent in subclasses with many other awards, particularly those of firms with low litigation costs. These effects have been particularly pernicious in emerging industries. Chronically strained for resources, USPTO officials are unlikely to assign many patent examiners to emerging technologies in advance of a wave of applications. As patent applications begin flowing in, the USPTO frequently finds the retention of the few examiners skilled in the new technologies difficult. Companies are likely to hire away all but the least able examiners.

These examiners are valuable not only for their knowledge of the USPTO examination procedure in the new technology, but also for their understanding of what other patent applications are in process but not awarded. (U. S. patent applications are held confidential until time of award. ) Many of the examinations in emerging technologies are as a result performed under severe time pressures by inexperienced examiners. Consequently, awards of patents in several critical new technologies have been delayed and highly inconsistent. These ambiguities have created ample opportunities for firms that seek to aggressively litigate their patent awards. <https://assignbuster.com/small-business-innovation-and-public-policy-in-the-information-technology-industry-assignment/>

The clearest examples of this problem are the biotechnology and software industries. In the latter industry, examples abound where inexperienced examiners have granted patents on technologies that were widely diffused but not previously patented [see, for instance, the many examples chronicled in Aharonian, 1999]. It might be asked why policy-makers have not addressed the deleterious effects of patent policy changes. The difficulties that Federal officials have faced in reforming the patent system are perhaps best illustrated by the efforts to simplify one of the most arcane aspects of our patent system, the “ first-to-invent” policy.

With the exception of the Philippines and Jordan, all other nations award patents to firms that are the first to file for patent protection. The U. S. , however, has clung to the first-to-invent system. In the U. S. , a patent will be awarded to the party who can demonstrate (through laboratory notebooks and other evidence) that he was the initial discoverer of a new invention, even if he did not file for patent protection until after others did (within certain limits).

A frequently invoked argument for the first-to-invent system is that this provides protection for small inventors, who may take longer to translate a discovery into a completed patent application. While this argument is initially compelling, the reality is quite different. Disputes over priority of invention are resolved through a proceeding before the USPTO’s Board of Patent Appeals and Interferences known as an interference. The Board will hold a hearing to determine which inventor first made the discovery.

The interference process has been characterized as “ an archaic procedure, replete with traps for the unwary” [Calvert, 1980]. These interferences consume a considerable amount of resources: the adjudication of the average interference is estimated to cost over one hundred thousand dollars [Kingston, 1992]. Yet in recent years, in only about 55 cases annually has the party that was second-to-file been determined to have been the first-to-invent [Calvert and Sofocleous, 1992]. Thus, the U. S. persists in this complex, costly, and idiosyncratic system in order to reverse the priority of 0. 3% of the patent applications filed each year. But this system has proved very resistant to change. At least since 1967, proposals have been unsuccessfully offered to shift the U. S. to a first-to-file system. As recently as January 1994, USPTO Commissioner Bruce Lehman was forced to withdraw such a proposal. While the voices raised in protest over his initiative??? as those opposing earlier reform attempts??? were led by advocates for small inventors, it is difficult not to conclude that the greatest beneficiary from the first-to-file system is the small subset of the patent bar that specializes in interference law.

It may be thought puzzling that independent inventors, who are generally unable to afford costly litigation, have been so active in supporting the retention of “ first-to-invent. ” A frequently voiced complaint is that small inventors take longer to prepare patent applications, and hence would lose out to better-financed rivals, in a “ first-to-file” world. This argument appears to be specious for several reasons. First, economically important discoveries are typically the subject of patent filings in a number of countries. Thus, there is already an enormous pressure to file quickly.



Second, the recent reforms of the U. S. system have created a new provisional patent application, which is much simpler to file than a full-fledged application. Finally, as former Commissioner Lehman notes, many most vocal independent inventors opposing patent reform are “ weekend hobbyists . . . [rather than representatives of] knowledge-based industries” [Chartrand, 1995]. As this case study suggests, the failure of Federal reform efforts is due to several factors. First, the issues are complex, and sometimes difficult to understand.

Simplistic claims frequently cloud these discussions. For instance, because firms use patents to protect innovations, it is frequently argued that a stronger patent system will lead to more innovation. Second, the people with the greatest economic stake in retaining a litigious and complex patent system??? the patent bar??? have proven to be a very powerful lobby. The efforts of the highly specialized interference bar to retain “ first to invent” is a prime example. Finally, the top executives of technology-intensive firms have not mounted an effective campaign around these issues.

The reason may be that the companies who are most adversely affected are small, capital-constrained firms who do not have time for major lobbying efforts. Thus, an important policy concern is that we avoid taking steps in the name of increasing competitiveness that actually interfere with the workings of innovative small businesses. The 1982 reform of the patent litigation process appears to have had exactly this sort of unintended consequence.

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