



U.S. Small Business Administration  
Office of Advocacy

February 2000

# **A New View of Government, University, and Industry Partnerships**

*A working paper on improving the relationship  
between research universities and the small business  
sector for the mutual benefit of all.*

The Office of Advocacy of the U.S. Small Business Administration was established in 1976 by Congress under Public Law 94-305 to, among other things, examine the current role of small business in the economy, present current and historical data on the small-business sector, and identify economic trends which will or may affect the small-business sector and the state of competition. In fulfillment of this mandate, the Office of Advocacy funds research and publishes reports, such as *The State of Small Business*, *Small Business Profiles*, the *Small Business Answer Card*, and *Small Business Economic Indicators*.

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# **A New View of Government, University, and Industry Partnerships**

Office of Advocacy  
U.S. Small Business Administration  
Washington, D.C.: 2000

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## **ABSTRACT**

A proposal is presented to encourage an improved relationship between the research universities and the small business technology sector for mutual benefit. Data is presented on the contribution of the universities, small businesses, and large businesses to the research agenda of the nation. The Small Business Innovation Research (SBIR) program is discussed including analyses of the program by the General Accounting Office (GAO), and reports by the National Institutes of Health (NIH) and Department of Defense (DOD). University collaborations with large and small businesses leading to the creation of the Route 128 (MIT, Boston, MA) area and Silicon Valley (Stanford, Palo Alto, CA) are reviewed, with an update of the impact on creating a new model of cooperation by the leadership at the University of California, San Diego, CA (USCD).

## **Executive Summary**

### **Developing Bridges Between Universities and Small Businesses**

**The United States is unique in the international technology marketplace with a world-class university academic base; large businesses with global market positions; small businesses with rapid, efficient innovation processes; good federal government support for research; and states actively supporting technology economic development. Some large research universities have fought the development of the SBIR program since its inception. This has resulted in a backlash from the small business community. These conflicts have sent a mixed message to Congress and to the public on the value of both entities to the R&D process. A proposal to create bridges, rather than walls, between these organizations is advanced to help ensure that the importance of the federal R&D funding of the entire continuum of the U.S. innovation process is communicated well to Congress and the public.**

The research and innovation community of the United States has evolved from one traditionally dominated by research universities and large companies, to one that has a continuum of research universities, federal laboratories, small and large businesses, and states supportive of technology economic development. The growing importance of the entrepreneurial small businesses to the rapid introduction of new, innovative products to the marketplace is described. Small businesses are creating not only new markets, but also new jobs, and are a vital element of the U.S. economic growth. Research shows that small businesses are the most productive sector of the United States in bringing new innovations to the market. Yet, the small business share of federal R&D funds is less than four percent, much less than their share of technology employment or share of industrially funded R&D—and it has been static for almost twenty years.

The U.S. university system is unequalled in the world and is vital to the continuation of our global competitiveness. The close ties between the universities and the industries—large and small—were integral to the successes of Silicon Valley and the Route 128 area of Massachusetts, and more recently, San Diego. Large businesses contribute not only technological innovation, but also access to markets, both domestic and global, for their own products and for those licensed or acquired from small businesses and universities.

Some large research universities, their supporters and their lobbyists have fought the development of the SBIR (Small Business Innovation Research) program since its inception. This has resulted in a backlash from the small business community. These conflicts between some universities and some small businesses have created confusion in Congress and the public on the value of both organizations to the R&D process. This confusion erodes needed support for the federal funding of R&D.

A proposal to create bridges, rather than walls, between these entities is advanced. Congress and the public must understand the importance of the federal funding of the entire continuum of the R&D process. The competition should be in the global arena, not in our national research community. Together we should be communicating the value of increasing the slope of the federal R&D funding curve—not fighting over it.

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Note: This paper was submitted as written testimony by Jere Glover, Chief Counsel of the Office of Advocacy, in support of the Senate Committee on Small Business Roundtable Discussion on the SBIR program conducted by Senators Christopher S. Bond, Chairman, and John F. Kerry, Ranking Minority Member, on August 4, 1999.

Earlier versions of this paper were presented at:

- The Government-University-Industry Research Roundtable, Governor Richard Celeste, Chair, at the Council Meeting on New Patterns and Opportunities in Industrial Research Funding sponsored by the National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine on March 12—13, 1997;
- The Sigma Xi Forum on Trends in Industrial Innovation; Industry Perspectives and Policy Implications, November 20—21, 1997, Washington, DC;
- The Marine Institute, Dublin, Ireland, Conference on the Year of the Ocean—1998, December 1—2, 1998; and
- The Ministry of Industry, Norway, December 3—9, 1998.

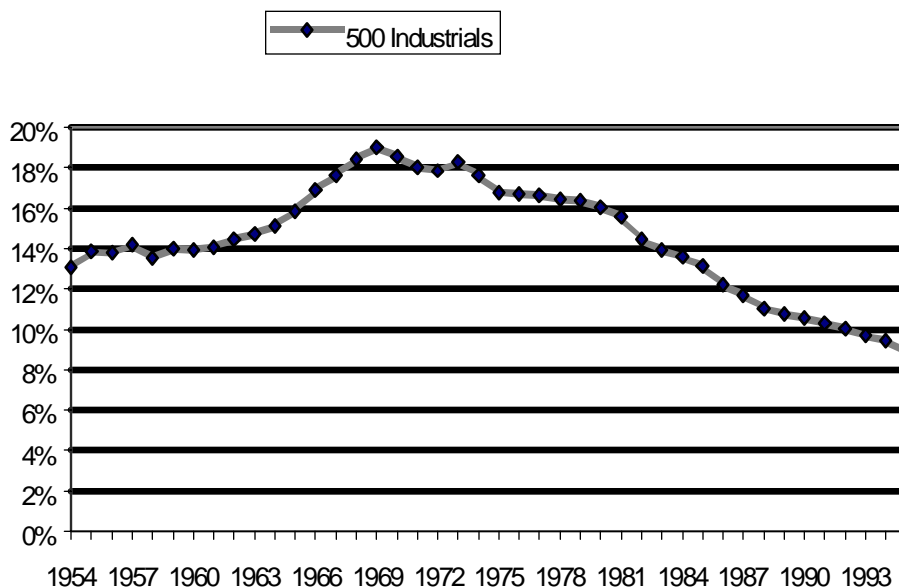
Suggestions and critique from attendees at these meetings are gratefully acknowledged. Comments are solicited to help make this paper better and to improve the dialogue on this topic. Please contact the author at [terry.bibbens@sba.gov](mailto:terry.bibbens@sba.gov) or 202-205-6983.

# A NEW VIEW OF GOVERNMENT, UNIVERSITY AND INDUSTRY PARTNERSHIPS<sup>1</sup>

## 1. Changes in the Importance of Small Business to the U.S. Economy.

The impact of the *Fortune 500* has declined in the past thirty years, and the small business share of the U.S. economy has grown to about half over this same period. New data shows that in the past seven years the small business sector has created essentially all of new jobs in the United States.

After World War II the dominant growth in the business sector was from large business. As shown in Figure 1, the *Fortune 500* industrial companies' percentage of the civilian employment grew from thirteen percent in 1954 to nineteen percent in 1969.



Source: Office of Advocacy, Economic Research, U.S. Small Business Administration;  
From *Fortune Magazine* and U.S. Census Bureau Data.

**Figure 1. *Fortune 500* Industrial Companies: Percent of Civilian Employment**

<sup>1</sup>This document is a working paper intended to encourage dialogue on the subject. The author is Terry Bibbens, The Entrepreneur in Residence, Office of Advocacy, U.S. Small Business Administration, and the views presented herein are those of the author and do not necessarily reflect the views of the Office of Advocacy or the U.S. Small Business Administration.

This paper is dedicated to Milton D. Stewart, the original Chief Counsel of the Office of Advocacy when Congress first established it on June 4, 1976, under Public Law 94-305. His tireless efforts on behalf of the small business community and his pioneering work in the SBIR legislation have been an inspiration to many of his followers in the support of the small business sector. I am pleased to count myself as one of his many converts to this effort.



Some of the key factors involved in this growth of large businesses after WWII were:

- A relatively low level of global competition after World War II as other nations' industries focused on rebuilding their factories and markets.
- A growing market in the United States as the demand for consumer products continued after the lean times of the depression of the 1930s.
- The growth of the post-World War II consumer market.
- A relative stability in the growth of new technologies.

However, from 1969 to the present time, the percentage of civilian employment by the *Fortune 500* industrial companies has steadily declined from the high of nineteen percent in 1969 to less than nine percent in 1995. This reflects the growing global competition that has resulted in the streamlining and improved productivity of these large companies with the necessary reductions in staffing. Newer, smaller companies have entered the market with innovative products and captured market share. The entrepreneurial start-ups, with venture capital support, have changed the face of the U.S. economy.

The change in employment percentage of the largest U.S. industrial companies means that other, smaller companies are becoming more important to the nation's economy. In fact, small business now accounts for slightly over half of the U.S. economy as shown in Table 1.

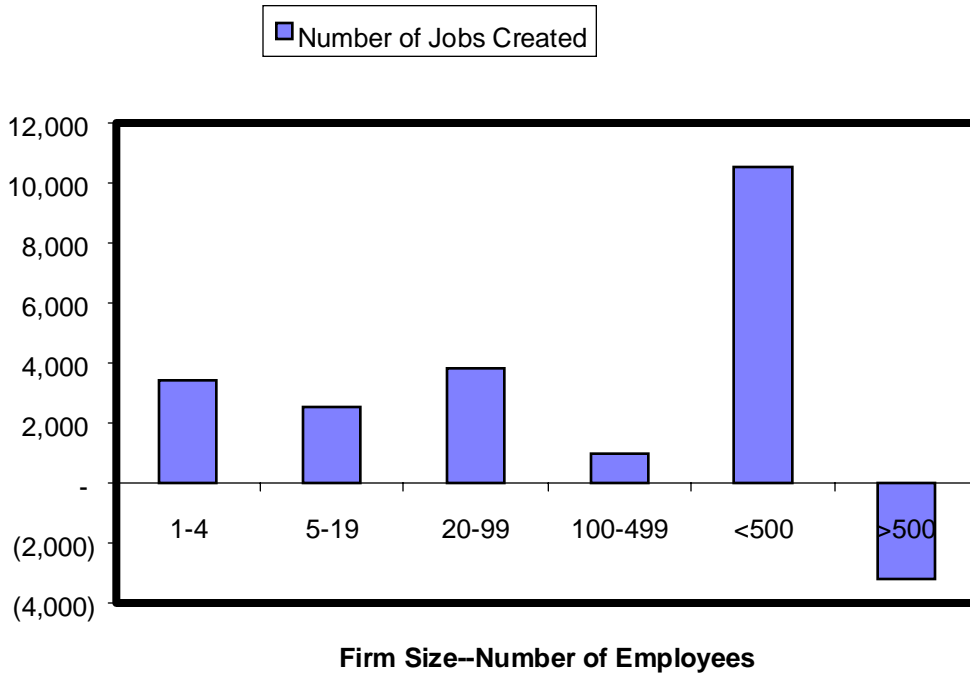
**Table 1. Small Business Contribution to the U.S. Economy.**

<b>Private Work Force Employment</b>	<b>53 percent</b>
<b>National Sales</b>	<b>47 percent</b>
<b>Gross Domestic Product</b>	<b>51 percent</b>
<b>New Innovations</b>	<b>55 percent</b>

Source: Office of Advocacy, U.S. Small Business Administration, Fact Sheet, 9/97

Small businesses are also producing innovative new products at a faster rate than large businesses. The rapid rate of change in technology has resulted in the introduction of a wealth of new products that match the dynamic nature of small businesses. Many of these new technologies were first investigated in research universities and then commercialized by the small business sector. As the mass markets adopt some of these innovations, the large business sector plays a major role in the global market development.

Small businesses have been the major source of job creation in the past few years, as shown in Figure 2.



Source: Cognetics, Inc., Cambridge, MA; Office of Advocacy, Economic Research Contract, 1997, U.S. Small Business Administration.

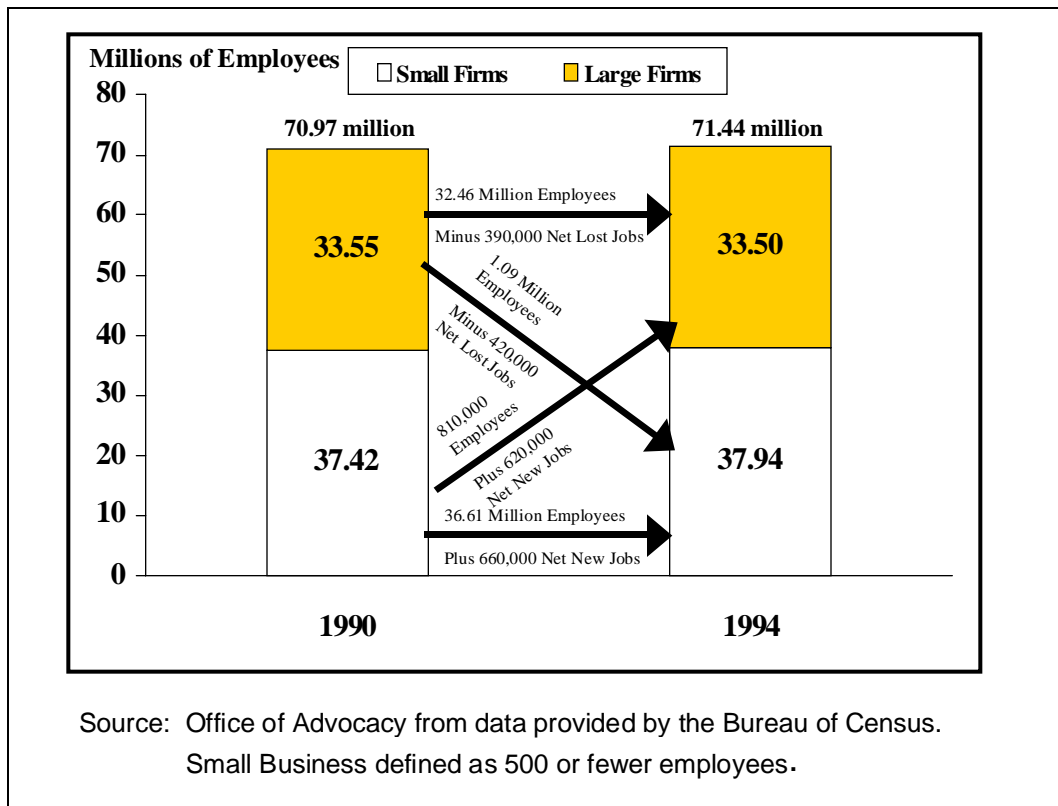
**Figure 2. Job Creation by Firm Size, 1991-1995 (Thousands)**

During the period from 1991 to 1995, small businesses created slightly over 10.5 million new jobs, whereas large companies had a net job loss of approximately 3.2 million, for a net job creation total of 7.3 million.

In a new study by the Office of Advocacy on *Mergers and Acquisitions in the United States, 1990—1994*, the importance of small business in the job creation role is clearly identified. This study, by Alicia Robb<sup>2</sup> of the Office of Economic Research, Office of Advocacy uses the newly available Business Information Tracking System (BITS) files to provide an overview of the frequency and impact of mergers and acquisitions by industry and firm size. The Office of Advocacy developed these files in cooperation with the Center for Economic Studies at the United States Census Bureau.

<sup>2</sup> *Mergers and Acquisitions in the United States, 1990-1994: An analysis of business acquisition activity by firm size and industry*, Office of Advocacy, U.S. Small Business Administration, October 1998. Technical questions on this report can be addressed to the Principal Investigator, Alicia Robb, at [alicia.robb@sba.gov](mailto:alicia.robb@sba.gov). The full text of this report is available on the Office of Advocacy's Internet site at <http://www.sba.gov/ADVO/>.

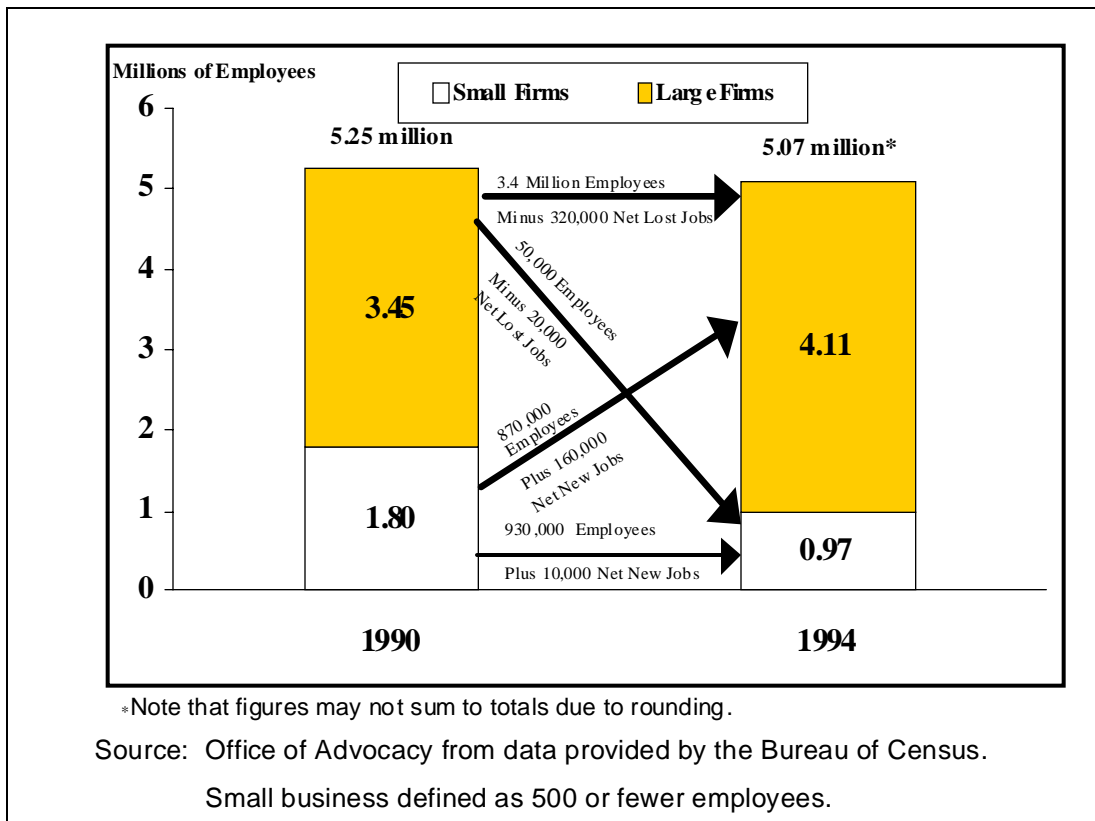
The report clearly shows that the small business sector created essentially *all* of the net new jobs in the 1990 to 1994 period. The summary data is shown in Figures 3 and 4.



**Figure 3. Movement of Employment in Surviving Non-acquired Establishments Between Small and Large Firms, 1990—1994**

It is interesting to note that the static 1990 and 1994 information would tend to make one think that large businesses are equal to small businesses in job creation, and in the case of mergers, have created the most jobs. From Figure 3, which shows the companies that were in existence as independent entities in both 1990 and 1994, the static analysis would indicate that the large businesses lost only about 50,000 jobs out of 33.5 million jobs, and small businesses created about 500,000 jobs out of 37.5 million jobs. However, the dynamic analysis of Figure 3 shows that large businesses lost a total of 810,000 jobs in these four years and small businesses created a total of 1,280,000 jobs. The *border crossers*, those that grew to be above the 500-employee threshold, added 620,000 jobs. They are properly counted in the 1994 census as large companies, even though they started the period as small ones.

In Figure 4, which shows the merged companies, the static analysis indicates that in 1994 the companies with more than 500 employees total 4.11 million jobs, versus 3.45 million in 1990. This comparison of large and small businesses as a snapshot in time would indicate that large companies created the most jobs via merger. However, when the companies are tracked over time, the dynamic analysis shows that large companies lost 340,000 jobs, and small businesses added 170,000 jobs. The large companies also gained 870,000 jobs from the small businesses that were acquired.



**Figure 4. Movement of Employment in Surviving Acquired Establishments Between Small and Large Firms, 1990—1994**

Note that large companies that merged with other large businesses lost 320,000 jobs, whereas small companies acquired by large companies gained 160,000 jobs. A possible explanation is that mergers of large companies by other large companies tend to focus on improving efficiency of companies in the same market, thus resulting in layoffs and consolidations. Small companies acquired by large companies tend to provide new products and/or markets of strategic interest to the company and additional resources are provided to these acquisitions to pursue these new ventures.

The new Business Information Tracking System (BITS) files are allowing us for the first time to see the dynamics of the job creation in the business world. By tracking individual enterprises and establishments over time, it is possible to attribute job creation to the large and small business sectors, industry sectors, and geographic regions with a high degree of accuracy.<sup>3</sup>

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<sup>3</sup> For additional information on the Business Information Tracking System (BITS) files, contact Dr. Robert Berney, Chief Economist, or Bruce Phillips, Director of the Office of Economic Research, Office of Advocacy, U. S. Small Business Administration, at 409 Third Street, SW, Washington, DC 20416, phone 202-205-6533 or e:mail at [Robert.Berney@sba.gov](mailto:Robert.Berney@sba.gov) and [Bruce.Phillips@sba.gov](mailto:Bruce.Phillips@sba.gov).

## 2. Innovation by Small Businesses.

**Small businesses are the most productive sector of the United States in bringing new innovations to the market.**

The innovation productivity of small business is high as reported by the Office of Economic Research, Office of Advocacy, U.S. Small Business in the *1994 President's Report on the State of Small Business*, Chapter 3, Innovation by Small Firms: <sup>4</sup>

- Small firms produce fifty-five percent of innovations. Small firms produce twice as many product innovations per employee as large firms, including the employees of firms that do not innovate. This is also true of significant innovations.
- Small firms obtain more patents per sales dollar, even though large firms are more likely to patent a discovery, implying that small firms have more discoveries.
- Small research and development (R&D) firms are quite research intensive: the percentage of employees that are R&D scientists and engineers are 6.41 percent in small firms and 4.05 percent in large R&D firms.
- Large firms receive twenty-six percent of their research and development dollars from the federal government and are more dependent on federal R&D dollars than small firms, which receive only eleven percent of their R&D funds from the federal government.
- A federal R&D dollar to a small firm is more than four times as likely to be used for basic research as a federal R&D dollar to a large firm.
- The rate of return on R&D expenditures is twenty-six percent for both small and large firms, but only fourteen percent for firms not involved with a university. The estimated rates of return on total R&D for firms with a university relationship are thirty percent for large firms and forty-four percent for small firms.
- The average small enterprise with intellectual property has sixty-one employees with nineteen percent of the employees in R&D, and the average large enterprise with intellectual property has 12,879 employees with three percent of the employees in R&D. Innovations coming from small high-tech firms are expected to increase in the coming years as a result of the increase in the federal Small Business Innovation Research (SBIR) program. Under this program, federal agencies with large research and development budgets must direct

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<sup>4</sup> For more details, see the Office of Advocacy's Internet home page at <http://www.sba.gov/ADVO/stats/fact1.html>.

designated amounts of their R&D contracts to small firms—the source of fifty-five percent of innovations and new technologies.

- Congress in 1992 reauthorized the SBIR program to continue through September 30, 2000. Since the inception of the SBIR program in fiscal year 1983, almost \$4 billion in competitive federal R&D awards have been made to qualified small business concerns under the program.
- Among the important innovations by U.S. small firms in the twentieth century are the airplane, audio tape recorder, double-knit fabric, fiber optic examining equipment, heart valve, optical scanner, pacemaker, personal computer, soft contact lenses, and the zipper.

### 3. Small Business Contribution to the Innovation Process and the SBIR Program.

**The small business share of federal research and development funds is less than four percent, much less than their share of technology employment or share of industrially funded R&D. Small businesses now employ more degreed scientists and engineers than large businesses and more than universities and government laboratories combined. The innovation and patent rate for small businesses far outstrips their share of federal funding. Some opponents of the SBIR program recommend “graduating” successful companies out of the program—this makes no more sense than “graduating” the best research universities that continue to receive federal research grants.**

#### 3.1 Small Business Share of Research and Development Resources.

The small business share of scientists and engineers has steadily increased as large businesses have downsized and reduced their investments in corporate research laboratories. Many of the most famous corporate research laboratories have been spun out as independent companies (such as Lucent from the old Bell Labs) or dramatically reduced in size. Many large companies have adopted the strategy of acquiring or licensing market-proven technologies from small companies rather than concentrating their research dollars on in-house projects. The most recent data from the National Science Foundation shows that small businesses now employ more degreed scientists and engineers than large businesses, and more than the universities and federal labs combined.<sup>5</sup> The 1995 employment data is shown in Table 2.

**Table 2. Employment of Degreed Scientists and Engineers in the United States.**

<b>Organization</b>	<b>Percent Degreed Scientists and Engineers</b>
<b>Small Businesses (&lt; 500)</b>	<b>36 percent</b>
<b>Large Businesses (&gt;500)</b>	<b>32 percent</b>
<b>Academic Institutions</b>	<b>18 percent</b>
<b>Government Laboratories</b>	<b>14 percent</b>

This shift in the center of research talent from large companies to small companies is consistent with the recent rapid changes in the technology world. Small companies can attract some of the best scientists and engineers with stock options and equity participation in the start-up. These researchers enjoy the freedom and excitement of small, venture capital backed companies. The dynamic nature of Internet, biotech, software and related technologies fit the model of the United States entrepreneurial world better than the bureaucratic nature of large company, university or government laboratories.

<sup>5</sup> From National Science Foundation Internet web site at <http://srsstats.sbe.nsf.gov/>.

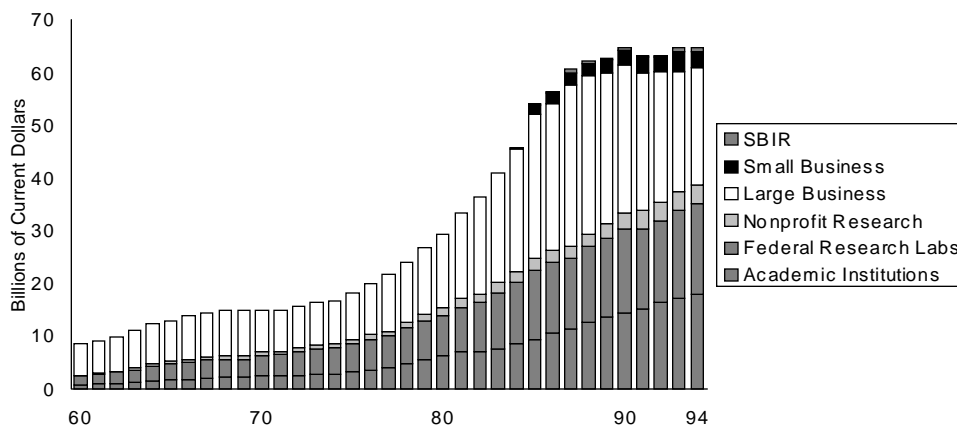


### 3.2 Small Business Share of Federal Research and Development Funds.

The small business share of federally funded research and development funding has historically been far below their contribution to the innovations, and below their share of the industrially funded R&D. According to the 1998 edition of the National Science Board’s annual publication, *Science and Engineering Indicators*,<sup>6</sup>

“Small firms (those with fewer than 500 employees) accounted for 14 percent of all non-federal R&D expenditures in the United States in 1995, up from 10 percent five years earlier.”

The small business share of federally funded research and development is still under four percent as shown in Figure 5.<sup>7</sup>



Note: Includes funds allocated to Federally Funded Research and Development Centers.  
 Source: U.S. Small Business Administration, Office of Advocacy, based upon data from the National Science Foundation, *Science & Engineering Indicators 1996*, Appendix Page 107; SBA Office of Technology Annual Reports.

**Figure 5. Allocation of Federal Research and Development Funds (1960 to 1994, Billions of current dollars)**

<sup>6</sup> *Science and Engineering Indicators*, National Science Board, 1998, is available from the U.S. Government Printing Office at 202-512-1800. Ask for stock number 038-000-00594-4. The cost is \$72 including postage in the U.S.

<sup>7</sup> The small business share of federal R&D funding (<4 percent) is much less than the small business share of all federal procurement—which was around 18.2 percent in 1998 (for contracts over \$25,000). The Office of Advocacy estimates a drop to around 17.8 percent in 1999 based on information provided by the procurement agencies. Department of Defense is the major source of federal procurement and their numbers (for contracts over \$25,000) have dropped even more. Prior to 1997 the small business share was about twenty-three percent of DoD procurement and this dropped to twenty-one percent in 1998 and is estimated to drop to nineteen percent in 1999. Since small business accounts for almost fifty percent of the sales in the United States, their share of federal procurement is below that which is desirable.

This is almost unchanged from the 3.5 percent determined by Congress over twenty years ago in joint hearings held on August 9 and 10, 1978, before the Senate and House Small Business Committees. These precedent-setting meetings of the Senate and House Small Business Committees studied the problems of federal procurement of R&D from small businesses and reported that:

“Small business received only about 3.5 percent of total federal research and development (R&D) funding. The most extreme example was the National Institutes for Health, which had no research contracts at that time with small business.”

“More than half of all scientific and technological developments in this century came from small business.”

“Small firms produced about four times as many innovations per R&D dollar as medium-sized firms, and about 24 times as many as the largest firms.”<sup>8</sup>

In their studies in 1978, Congress found that one of the major barriers that precluded small businesses from federal research funding was:

“A bias in favor of large firms and universities...as safer than small firms”

This barrier still exists today. It was true then, and still is generally true in the research agencies, that the safest approach for the project officer’s career is to give the contract to a large company or major research university. As the project manager or procurement officer you cannot be faulted if you awarded the contract to a large company or research university. If they fail, the conclusion is that “it obviously was an intractable research problem—no one could have solved it if they couldn’t.” However, if it is awarded to a small company, the decision can be criticized after the fact—even if the best researchers in the country were at the small company. In addition, since most government technology peer review panels of proposed research programs are composed of academics, they tend to favor proposals from other academic institutions.

### **3.3 The SBIR Program.**

The SBIR program was established in 1982 when Congress, with strong bi-partisan support, passed the Small Business Innovation Development Act (P.L. 97-219). President Reagan signed it into law on July 22 of that year. The fundamental purpose of the law was to ensure that federal R&D procurement officers and program managers made use of the wealth of resources available from small businesses in addressing the mission and research needs of their agencies. By ensuring that these agencies used the full spectrum

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<sup>8</sup> This discussion is from the July 1996 Technology Talk article entitled, *Innovation, Commercialization and SBIR: It’s “Déjà Vu All Over Again”* in the *Small Business Advocate* published by the Office of Advocacy, U.S. Small Business Administration.

of capabilities of universities, federal laboratories, large businesses and small businesses, Congress helped assure that the research resulting from the expenditure of taxpayers' dollars was maximized. The SBIR program solicitation topics are based on the mission and research needs of the participating agencies. The technical peer review ensures that only the best technology is funded. The competition is fierce for the SBIR awards, with only one in eight proposals winning an award.<sup>9</sup>

The Congressional foresight in requiring the federal research agencies to use small companies has been validated with the shift of the majority of our research talent from the large companies to the small companies. The rapid pace of technology product introductions by entrepreneurial small companies has changed the face of our consumer and industrial marketplace. Thanks to Congressional actions in 1982, the federal research agencies are also able to tap into this creative pool of talent to address national research priorities.

Table 2 and Figure 5 clearly demonstrate that the allocation of federal research and development funds to small business does not match their technology resources, which include:

- 36 percent of the degreed scientists and engineers
- 18 percent of the nation's industrial R&D work force
- 15 percent of the industrially funded R&D programs
- 4 percent of the federal R&D funds

### **3.4 SBIR Program Track Record.**

The SBIR program is helping to dispel the "safety" myth of paragraph 3.2. The GAO has studied and reported favorably on the SBIR program at least nine times since it was authorized in 1992. Their reports have documented that the quality of the research by the small companies is quite high as reported in *GAO/RCED-89-39*:<sup>10</sup>

"Overall [530 project officers providing 96 percent of the SBIR funding]... assessed 29 percent of the SBIR projects as being of higher quality than non-SBIR research and indicated that about half of the SBIR projects were similar in overall quality to other research. Project officers at all agencies rated SBIR projects substantially higher than other research under their responsibility regarding the potential for leading to invention and commercialization of new products, processes, or services, with NSF having the highest level."

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<sup>9</sup> *Twelfth Annual Report, 1994, Small Business Innovation Development Act*; Office of Technology, U.S. Small Business Administration.

<sup>10</sup> *GAO/RCED-89-39* is a major report by the U.S. General Accounting Office on the SBIR program published in 1989. Copies of this report may be obtained from GAO via their web site at <http://www.gao.gov> or by calling them at 202-512-6000.

In GAO report, *GAO/RCED-95-59*<sup>11</sup> (March 1995), GAO reported that:

“To date, it appears that the quality of research proposals has kept pace with the program’s expansion. GAO’s view is based on the (1) high level of competition, (2) large numbers of proposals that agencies deemed worthy of funding but that received no award [due to limitations of funds], and (3) views expressed by SBIR officials that quality is being maintained.”

### **3.5 SBIR Commercialization Rate.**

The commercialization rate for bringing products from the laboratory to the marketplace has been demonstrated to be quite high for small businesses. The commercialization rate of the SBIR program is the highest of any major federal R&D program: about twenty-four percent for single Phase I and II SBIR awards, and over forty percent for companies receiving multiple awards, according to the SBA’s Office of Technology.<sup>12</sup> According to a report by the GAO in 1998:

“The companies responding to GAO’s and DOD’s surveys reported that approximately 50 percent of their projects had sales of products or services related to the research or received additional developmental funding after receiving SBIR funding. In both the GAO and DOD surveys, approximately 35 percent of the projects had resulted in the sales of products or services, and approximately 45 percent of the projects received additional developmental funding.”<sup>13</sup>

### **3.6 Discussion Of “Graduating Out” Successful SBIR Companies.**

Some opponents of the SBIR program have incorrectly characterized it as a small business development program. They have extended this argument to suggest that companies should be limited in the number of SBIR contracts that they can receive. They propose that companies should “graduate” from the SBIR program. From a national public policy perspective it makes no sense to limit the number of research grants to Stanford, Harvard, MIT or any other major research university just because they have received a large number of previous awards. Nor does it make any sense to limit the number of SBIR awards to a small business. The SBIR program was designed by Congress to ensure that federal agencies used the creative talents of the small businesses

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<sup>11</sup> *GAO/RCED-95-59, Interim Report on the Small Business Innovation Research Program*, March 1999, U.S. General Accounting Office.

<sup>12</sup> Testimony of Daniel O. Hill, Assistant Administrator, Office of Technology, U.S. Small Business Administration on April 15, 1997, before the House Committee on Small Business.

<sup>13</sup> *GAO/RCED-98-132, Observations on the Small Business Innovation Research Program*, April 1998, by U.S. General Accounting Office.

in their R&D programs. “Graduating out” the successful companies would eliminate these proven valued resources from being able to address national research priorities.

It is important in this discussion to recall the Congressional findings cited above that led to the discussion surrounding the need for an SBIR program—namely that small businesses were being excluded from the federal R&D programs by biases toward large companies and universities. Congressional hearings uncovered an imperfection in the federal R&D procurement practices and Congress established the program to ensure that the taxpayers were able to receive the benefit of the advanced research and innovation produced by the small business sector.

Since those hearings in 1978 the small business sector has increased its share of scientists and engineers as reported by NSF (see Table 2). However, the R&D procurement biases against the small business sector have not changed for most agencies. Fortunately, there are some notable examples of support for the SBIR program and for the small business sector in the research agenda of some agencies. The National Institutes of Health conducted in-depth reviews of the SBIR program in 1997 and 1999 and reported:<sup>14</sup>

- NIH typically has the highest SBIR commercialization rate of any government agency.
- In concluding the January 27, 1997, SBIR Meeting at NIH, Dr. Wendy Baldwin, Deputy Director for Extramural Research, made it clear that the NIH is committed to the goals of the SBIR program and will continue to explore opportunities to further strengthen the program.
- The theme for the NIH SBIR/STTR Conference, January 11, 1999, was: Small Business and the NIH; Forming a Strategic Alliance for the New Millennium.

And, this was the agency that had *no* contracts with small businesses before Congress mandated the SBIR program.

The Department of Defense is another agency that has studied the SBIR program extensively and found it to be effective. The following is quoted from a speech by Paul J. Hoyer, Deputy Under Secretary of Defense (International and Commercial Programs).<sup>15</sup>

“...Over the coming year, this [SBIR] program will fund more than \$1 billion in R&D projects at small technology companies - R&D projects

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<sup>14</sup> See the NIH web site at <http://grants.nih.gov/grants/funding/sbir.htm> for more details on the NIH SBIR/STTR review conferences.

<sup>15</sup> “Harnessing Small Business Innovation for U.S. Economic and Military Strength,” remarks of Paul J. Hoyer Deputy Under Secretary of Defense (International & Commercial Programs) at the National SBIR Conference, Anaheim, CA, November 14, 1996. See <http://www.acq.osd.mil/ip/speeches/sbir.html> for the full text of the speech.

that serve a government need and also have commercial applications. In addition, the Small Business Technology Transfer program - "STTR" - will fund nearly \$70 million this coming year in *cooperative* R&D between small businesses and research institutions such as universities and federally-funded R&D centers. Together, the SBIR and STTR programs represent a major commitment by the federal government to harness one of the great economic resources in this country -- our small technology companies."

Hoepfer continued:

#### **“Effectiveness of SBIR in Harnessing Small Business Innovation**

When a billion dollars of taxpayer money is going towards something, it is a fair question to ask whether or not it works. The SBIR program does. If there is anything we are good at in government, it is doing studies. The General Accounting Office has looked at SBIR three times, in 1989, 1992, and 1995. Each time, the evaluation was favorable. In 1992, the National Academy of Sciences performed an independent evaluation and also concluded that the SBIR program is effective. On the basis of this evidence, in 1992 Congress reauthorized and expanded the SBIR program with broad bipartisan backing, based on its finding that SBIR is "one of the most effective technology programs in the federal government."

Within the DoD, we have been careful to check our own work. This past May, we conducted an evaluation to find out if the quality of the expanded SBIR program was equal to the previous, smaller program. We concluded that "the quality of DoD SBIR research since FY 1992 has kept pace with the program's expansion." Further, our assessment found that SBIR-developed technologies have resulted in significant improvements in U.S. military and economic capabilities and major savings to the taxpayer..."

These views were also reflected in testimony to Congress by The Under Secretary of Defense for Acquisition and Technology, the Honorable Paul G. Kaminski, as follows:<sup>16</sup>

#### **“Small Business Innovation Research (SBIR) Program**

This program is executed by the Services and Defense Agencies. Its objective is to involve small business in federal R&D, to increase the commercialization of technology developed by federal R&D, and to increase the use of commercial technology in defense systems. The program has been very successful and has resulted, for example, in

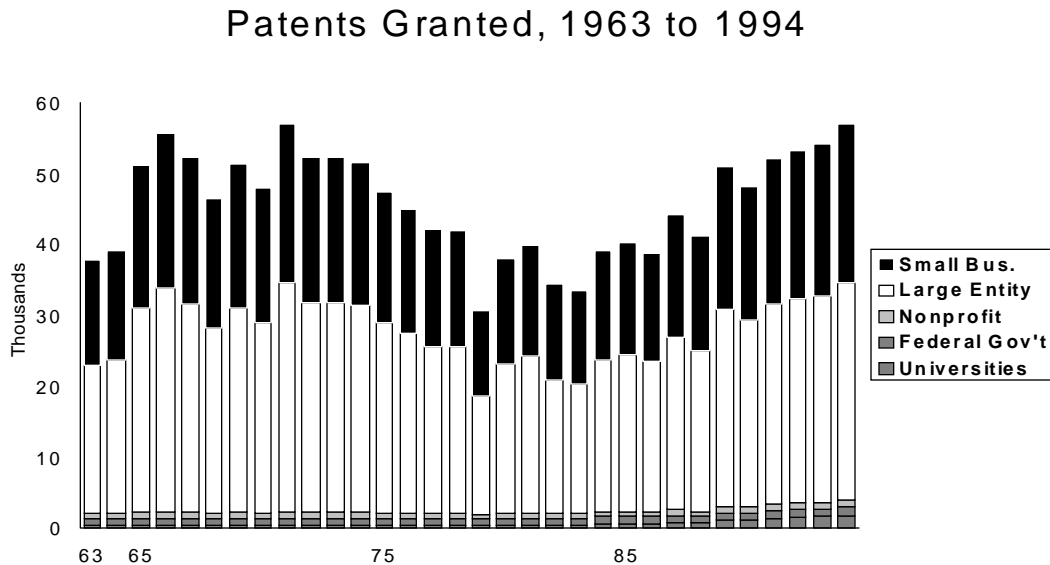
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<sup>16</sup> Statement of The Under Secretary of Defense for Acquisition and Technology, Honorable Paul G. Kaminski, before the Subcommittee on Acquisition and Technology of the Senate Committee on Armed Services on FY 1997 DoD Acquisition and Technology Program, March 20, 1996. For the full text of his testimony, see [http://www.acq.osd.mil/ousda/testimonies/97a\\_t\\_prg.doc](http://www.acq.osd.mil/ousda/testimonies/97a_t_prg.doc).

development of innovative fuel cell technology to produce electricity and water and lightweight head mounted displays. Under the SBIR program, DoD will fund approximately \$550 million in R&D projects at small technology companies in FY 1997--projects that serve a DoD need and have commercial potential.”

### 3.7 Innovation and Patent Track Record of Small Business.

In sharp contrast to the low percentage of federal R&D dollars allocated to small business is the high percentage of patents granted to small businesses and individual inventors.<sup>17</sup> As shown in Figure 6 small businesses and individual inventors account for approximately 38 percent of patents filed in the United States, yet receive only 4 percent of the federal R&D funding. Universities and federal labs receive only 3 percent and 2 percent respectively of the patents filed, for a total of 5 percent, while they receive approximately 28 percent and 26 percent of the federal R&D dollars respectively, for a total of approximately 54 percent of the funds.



Notes: Small business includes Individuals and Small Business. Utility patents only.  
 Source: Office of Advocacy, Economic Research, U.S. Small Business Administration, from data provided by the U.S. Patent and Trademark Office, Department of Commerce.

**Figure 6. Patents Granted by Type of Organization**

<sup>17</sup> Patents for small business and individual inventors are combined here since most individual inventor’s patents are commercialized through small businesses, and many small business owners file their patent in their own name, not the business. For 1994 the percentages of patents filed by “small entities,” the patent office’s name for small businesses, was sixteen percent and for individual inventors was twenty-two percent.

Universities have increased their efforts to obtain patents in the past ten years, as indicated by the increases during that period in Figure 6. However, even with this increased effort, universities have increased their patents from only one percent to three percent of the total patents granted.

Of course, universities also provide a unique service in the advancement of technology and innovations by requiring extensive publication of research efforts by their faculty and students. These papers form the basis of a wealth of research technical literature that is read worldwide. In addition, the research work of universities is often the basis of advanced products brought to market by large and small companies, with or without the benefit of patent protection.

One legitimate concern of publication of university research efforts is the fact that this research can benefit companies in other nations at the expense of U.S. taxpayers. The increased efforts to obtain patents by the universities help to allay these fears; however, it presents another concern to academics who wish to encourage the free flow of knowledge. Congressional actions such as the Bayh-Dole Act and the Robinson-Patman Act have helped to provide incentives to reward academic inventors and their laboratories through royalties for commercially viable patents.

The dramatic differences between the ratios for federal R&D dollars and patents awarded for the various organizations are shown in Table 3. Of course the patents granted to both small and large businesses and to universities reflect not only federal research funding, but also that funding received from industry. For businesses they also reflect investments received from venture capitalists. However, the comparison is enlightening.

	<b>Federal R&amp;D Dollars</b>	<b>Patents Granted</b>
<b>Small Business<sup>4</sup></b>	<b>4 percent</b>	<b>38 percent</b>
<b>Large Business</b>	<b>36 percent</b>	<b>55 percent</b>
<b>Non-Profit Labs</b>	<b>6 percent</b>	<b>2 percent</b>
<b>Federal Research Labs</b>	<b>26 percent</b>	<b>2 percent</b>
<b>Universities</b>	<b>28 percent</b>	<b>3 percent</b>

While patents are not the only indicators of commercial value of a new innovation, they at least indicate that the inventor believes that the innovation warrants the expense of protecting the idea in the marketplace. In the global battles for economic competitiveness, the patent is the weapon of choice, as indicated by the large number of patents filed in the United States by foreign companies.



To a small business the decision to file a patent is a business decision that is not taken lightly. The financial resources and management and technical staff time required to pursue a patent are the most precious and the scarcest resources of a small company. For this reason many small companies look carefully at the risk/return ratio on filing of patent applications in foreign countries. In a study conducted for the Office of Advocacy, it was reported:

“Interviews also revealed that small companies that file foreign patent applications often encounter problems, mainly cost and difficulties in getting adequate protection. Although they face the same problems, large companies have more resources to deal with them than do small businesses. This suggests that small businesses with valuable inventions face special barriers in obtaining foreign patent protection because of their limited resources.”<sup>18</sup>

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<sup>18</sup> *Foreign Patenting Behavior of Small and Large Firms*, Mogue Research and Analysis Associates, under contract to the Office of Advocacy, U.S. Small Business Administration, 1996.

#### **4. The University Contribution to the Innovation Process.**

**Universities play a major role in the innovation process by the education of scientists and entrepreneurs, and in performance and publication of research programs—from basic to applied. The U.S. university system is unequalled in the world and is vital to the continuation of our global competitiveness. The close ties between the universities and the industries—large and small—were integral to the successes of Silicon Valley and the Route 128 area of Massachusetts, and more recently, in San Diego.**

##### **4.1 The University Role.**

Universities play a large role in the research agenda of the United States. They are the source of education for almost all of the bright young minds that create these new technologies and that start small companies that fuel the economic engine of our nation. The U.S. universities are a unique tool in the nation's global competitiveness and are second to none in the world.

The research conducted at the universities and colleges in the United States is also world-class work and is the underpinning for many of the new technologies that spawn our start-up companies and industries. More universities are working to improve their relationship with small businesses as the awareness grows of the importance of these small companies in the introduction of new breakthrough technologies to the marketplace. Most research universities have established technology transfer departments to help formalize the process of commercializing research work to obtain royalty income to support additional programs. Many of these technology transfer departments are finding that small businesses are the most productive entity to bring some of the newest technologies to the markets. The small businesses are demonstrating the pioneering skills necessary to open new markets, which may ultimately be fully exploited by partnerships or mergers with larger global companies.

##### **4.2 Silicon Valley and Route 128 Technology Clusters.**

The partnerships between universities and small businesses (and large businesses) have created clusters of technology and economic growth that are the envy of the world. Two prime examples are Silicon Valley surrounding Stanford, and the Route 128 area surrounding the Massachusetts Institute of Technology (MIT). A key ingredient of the success of the development of these clusters is the permeability of MIT and Stanford to the large and small businesses in the regions. The free flow of ideas and interesting technical activities between the faculty, students, and the industry has created a uniquely vibrant technical climate.

[My perspectives of Silicon Valley are from first-hand experience in this region over most of my career. I obtained my BSEE from Stanford in 1958 and spent 25 years of my career in Silicon Valley, including founding, successfully growing and merging a company, managing a large division of a *Fortune 500* company, and participating as a board member to some companies and as an investing “angel” to others. The permeability of the Stanford faculty and students to the small industries was a normal course of business in all activities in the region and it was not until I moved to other parts of the country that I observed how unique and valuable this phenomenon is.]

Tradition on the Stanford campus and in Silicon Valley was that this ease of access was due in no small part to the style of Stanford Dean and Provost, Dr. Frederick Emmons Terman (1900—1988).<sup>19</sup> He recruited much of the early Stanford Electronics Department faculty from scientists who had spent the war years at the MIT Radiation Laboratory (MIT Rad-Lab). Dr. Terman was a student of Dr. Vannevar Bush, famed for his leadership of the national technology agenda during World War II and father of the U.S. model of the research community after the war.

Working closely with the founders of what were small companies then—such as Varian Associates and Hewlett-Packard—Dr. Terman and Stanford developed a tradition for permeability of the traditional walls between the academic community and industry. These traditions of openness and close cooperation between the academic members and industry leaders, borne of the necessities of World War II and the cold war, were invaluable to the creation of clusters of leading technology companies in these two regions.

MIT Rad-Lab, in the Boston area, was one of the fabled university/industry teams of World War II that were instrumental in fielding new technologies much faster than traditionally accomplished by other organizations. The permeability of the university/industry/government complex during this time was a natural patriotic duty to ensure that our fighting forces had the latest and most advanced technologies. After WWII the connectivity continued and spawned many new Route 128 companies that changed the course of computing in the world—including Digital Equipment Corporation, Data General, and Wang.

A good description of the value of these universities’ graduates to the economic competitiveness of the United States is provided in *MIT-The Impact of Innovation*.<sup>20</sup> In the Executive Summary, this report states:

“If the companies founded by MIT graduates and faculty formed an independent nation, the revenues produced by the companies would make

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<sup>19</sup> Dr. Terman has been called “The intellectual father of Silicon Valley” by many in the region; see the Internet site: <http://www.commerce.digital.com/palo-alto/historical-assoc/centennial-bios/FredTerman/bio.html> .

<sup>20</sup> *MIT: The Impact of Innovation*; A BankBoston Economics Department Special Report, March 1997.

that nation the 24<sup>th</sup> largest economy in the world. The 4,000 MIT-related companies employ 1.1 million people and have annual world sales of \$232 billion.

Eighty percent of the jobs in the MIT-related firms are in manufacturing (compared to 16 percent nationally) and a high percentage of products are exported.

MIT-related firms account for about 25 percent of sales of all manufacturing firms in the state [Massachusetts] and 33 percent of all software sales.”

Where close cooperation between industry and universities has developed, strong technology clusters have emerged. Where the academic institutions have had a more cloistered strategy, the clusters have not been forthcoming.

A good analysis of what a region can do to encourage technology clusters was presented by Ioanna T. Morfessis in the paper, *A Cluster-Analytic Approach to Identifying and Developing State Target Industries: The Case of Arizona*,<sup>21</sup> in which she states:

“The accelerating pace of technological change makes the innovation process particularly important, which in turn makes timely access to R&D and new process and product technologies crucial. A state must have access to technology resources at every level—from basic research to applied research and development to the latest generation of ‘off-the-shelf’ equipment—to meet the wider variety of needs in its economy.

Priority technology foundation initiatives focus on improving K-12 math and science education, encouraging university research with economic impact, strengthening the Governor’s Council on Science and Technology, developing a state-wide university-industry technology transfer strategy, and supporting the growth of young technology-based companies in Arizona.”

### **4.3 Characteristics of Successful Clusters.**

One characteristic of the successful clusters is the inclusive nature of the team that contributes to the growth. From the experience of those of us lucky enough to participate in the unique Silicon Valley environment, it was clear to us that not only could we expect unqualified support from Stanford, we could also find knowledgeable experts in the following fields including:

- Attorneys with skills in corporate securities laws, venture and angel (private) financing, R&D partnerships, intellectual property protection, joint ventures,

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<sup>21</sup> *Economic Development Review*, Spring, 1994, pages 33 to 37.

marketing agreements, international relationships, and other activities important to a technology cluster.

- Accounting firms with skills mirroring the attorneys and with knowledge in accounting practices important to these activities, including government contracts and grants, depreciation and revenue recognition practices for new technologies, and tax implications of various types of partnerships and investment tools.
- Bankers who knew how to value technology and joint venture arrangements, and collateralize inventory of high-value components—including the skills to know when a particular technology had reached the limit of its value.
- Real estate developers and builders who knew how to build the unique facilities required for computer chip and biotech laboratories and manufacturing operations, and who had the skills and interest to help city and county governments understand the need for zoning ordinances that brought these high-value companies to the region.
- Venture capitalists and angel investors who knew the technologies and were willing to back the high-risk ventures that pioneer these market shifts.
- State and community colleges that were willing to develop educational programs to fill the needs of rapidly growing companies. These included developing the business management programs to turn technology entrepreneurs into business people capable of understand balance sheets and securities transactions, and providing training programs for first-line managers, lead supervisors, and technicians. The support staffs were developed with training programs for quality control technicians, accountants trained to understand the arcane nature of these new industries, and the other skills necessary for the growth of an industry.
- The industry associations which provided the networking meetings permitting the industry participants to meet each other, and to meet leaders of the support network needed to grow businesses. These associations also helped educate the political leaders in the community, state, and nation in the importance of these technologies.

The combination of world-class universities closely coupled to the business community and supported by the service provider networks has been proven to be the ingredients necessary to build successful clusters.

While university technology transfer offices are necessary to ensure that new technologies are licensed, they are not sufficient to develop clusters. Experience and

studies have shown that clusters develop around universities because of the personal interfaces between faculty and students, and the entrepreneurs who start small companies. Universities with permeable environments develop clusters. Those with insular environments do not—regardless of the competency of their technology transfer offices. The universities with strong technology clusters create an exciting environment that fosters research programs. This brings returns to the university by attracting top researchers, financial returns to the entrepreneurs and their investors with exciting new products, and economic and social returns to the local community with quality jobs and CEOs interested in furthering the quality of life in their home towns.

#### **4.4 A New Model of Cluster Development at UCSD.**

A new model of excellence in development of the technology cluster is the environment surrounding the University of California at San Diego, California (UCSD).<sup>22</sup> Under the leadership of former Chancellor Dr. Richard Atkinson (now President of the University of California System), UCSD changed from an insular campus to a permeable one in the short span of ten years. With strong encouragement from the local industry and political leaders, Dr. Atkinson developed structures that encouraged cooperation between the researchers at the university and the industry.

The resultant dramatic impact on creating clusters of new technology industries—bio-tech, wireless communications, software and multi-media—has changed San Diego from being a “division” town of defense companies to a “local CEO” town with strong support for all local initiatives from the arts to education to the business climate. Before Dr. Atkinson’s tenure, UCSD was not connected to the local technology community, as witnessed in the debriefings to the industry leaders by the government agencies when San Diego lost the Sematech and MCC competitions to Texas.<sup>23</sup>

When the defense downsizing of the early 1990s hit San Diego, it resulted in major losses of jobs when the divisions of General Dynamics were sold off and moved out of town. The groundwork laid by the efforts of Dr. Atkinson and the UCSD-CONNECT program in building technology clusters paid off well in the development of new “home-grown” entrepreneurial start-ups. The service sector and local government support were vital in turning around one of the nation’s worst unemployment records of the post cold war period into currently one of the best job creation environments in the country. The creation of entrepreneurial wealth, exciting research projects, and expansion of high-

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<sup>22</sup> For a detailed report on the San Diego evolution, see *Developing High-Technology Communities in San Diego: A report on the strategies and actions leading to the growth of robust technology clusters in San Diego* by Innovation Associates, February 2000, produced under contract to and available from the Office of Advocacy, U.S. Small Business Administration, 409 Third Street, SW, Washington, DC.

<sup>23</sup> I witnessed this insular academic environment first hand when I came to San Diego in 1982 to run a division for a *Fortune 500* company. The difference between the Stanford-Silicon Valley environment and the UCSD-San Diego environment could not have been more stark in 1982. The change to the current permeable environment under Dr. Atkinson’s tenure shows the positive impact of strong leadership on both the university and the business community.

paying jobs has made San Diego a model of envy around the world. And, the local CEOs are contributing to the improvement of the quality of life so important to the region.

The promotion of Dr. Atkinson to the President of the University of California System is an indication of the importance of his work in San Diego. Of special interest to leaders wishing to build successful clusters in their regions is the fact that the UCSD/San Diego accomplishments were built without any outside funding, and without requiring the unique WWII and cold war events that preceded the Route 128 and Silicon Valley models. UCSD and San Diego showed that bootstrapping can be accomplished through the vision and work of strong leaders.

## 5. Large Businesses' Contribution to the Innovation Process.

**Large businesses contribute not only technological innovation, but also access to markets, both domestic and global, for their own products and for those licensed or acquired from small businesses and universities.**

Large businesses have traditionally been major contributors to the production of new innovations and introduction of new products to their traditional markets. However, as the global competition has strengthened, many of the large well-known corporate laboratories have been reduced in size or even spun off into separate entities. Large corporations have increased their “out-sourcing” of product development and their acquisition of products by licensing and/or acquisition of other, smaller companies.

Many large, global companies have found that it is a better use of their money to acquire the technologies and products from small companies rather than risk development projects in their captive labs. In their laboratories they are required to fund a wide variety of products, including a hefty percentage that will prove to be unsuccessful. If they have one out of four succeed, large companies generally consider their product management and research programs to be highly successful. If they wait to let a small company pioneer the product and market, they can select only the winners that fit their market priorities. They may have to pay a premium to acquire this one winner, but they don't have to pay for the three out of four losers in their labs.

Large businesses remain the primary vehicle to bring new products to the mass and global markets. Even products that were not initially developed by large companies are usually finally marketed to the mass markets by the dominant companies in those markets. The introduction of the personal computer by Apple, and the current dominance of the IBM-compatible PC is a typical evolution of a technology into a new market. A study by the National Academy of Engineering reported:

“The principal economic function of small, entrepreneurial, high-tech companies is to probe, explore, and sometimes develop the frontiers of the U.S. economy—in products, services, technologies, and markets—in search of unrecognized or otherwise ignored opportunities for economic growth and development.”<sup>24</sup>

The small businesses may bring the innovative product to market and initially sell to the “early adopters” that help pioneer a small market. However, it is usually a large company with global marketing experience and clout, and with strong financial resources that brings the product to the mass market.

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<sup>24</sup> *Risk and Innovation, The Role and Importance of Small High-Tech Companies in the U.S. Economy*, Committee on Technology, Management, and Capital in Small High-Tech Companies, National Academy of Engineering, National Academy Press, 1995; page 4.



Therefore, a growing synergy between the innovative productivity of small businesses, and the financial, legal, and marketing clout of large businesses is strengthening the global competitiveness of the United States. In studies conducted by and for the Office of Advocacy, the “capital chasm” facing the small companies that are developing new technology products is often solved by teaming with, licensing to, or becoming acquired by a large business.<sup>25</sup> The average venture capital (VC) investment in a technology company in 1997 was over \$13 million and the VC interest was primarily in those companies capable of an IPO (Initial Public Offering) in a few years. Many small technology companies with exciting new products were below the threshold for the venture capitalists. Their choice for obtaining growth capital often was limited to being acquired by a larger company interested in their products and markets.

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<sup>25</sup> See the Access to Capital Electronic Network Internet home page at: <http://www.ace-net.org> for information on the equity capital shortfalls for small businesses, and the recent developments in the “angel” capital market. Additional information is available from the Office of Advocacy, U.S. Small Business Administration, in the “*Conference Report for The Angel/Seed Capital Connection*,” September 15, 1997.

## **6. Developing Bridges Between Universities and Large and Small Businesses.**

Some large research universities have fought the development of the SBIR program since its inception. This has resulted in a backlash from the small business community. These conflicts have sent a mixed message to Congress and the public on the value of both entities to the technology creation process. A proposal to create bridges, rather than walls, between these entities is advanced to help ensure that the importance of the federal funding of research and development of the entire continuum of the U.S. innovation process is communicated well to Congress and the public. The important issue is the value of maintaining or strengthening our global competitiveness via a strong national R&D program.

For the continued growth of a strong and dynamic technology sector in the United States, it is necessary to:

- Continue the funding of the research and education components of the universities;
- Ensure that university and industry ties are strong;
- Provide the maximum resources possible to the solution of the research problems of the federal agencies.

A strong team of universities and industry—large and small—is important to this process. Artificial barriers between any of these groups serve the taxpayer poorly.

It is clear from a number of studies by federal agencies, public/private think tanks, and universities, that maintaining the technology leadership in the world economy is important to the citizens of the United States. Our global competitive advantages come not from low-priced labor or low-cost natural resources, but from the productivity of our industries and workers, and the technological leadership of our products and services. Maintaining the desired growth of the standard of living and the stringent environmental controls important to the U.S. public means ensuring that our technological leadership remains strong.

Clearly the combinations of government laboratories, research universities, small businesses, and large businesses have a stake in this process. They also represent the best force to jointly communicate the importance of continued growth in federally funded research and development to our global competitiveness and growth in standard of living. Unwarranted attacks by one group on the other in the interests of attempting to position one group ahead of the other in the funding chain merely confuse the issues before our legislators—probably resulting in fewer R&D funds for all. What is needed is a clear statement by all parties—universities, federal laboratories, and industry, large and small—on the importance of a strong research and development agenda for the United States.

The numbers are on the side of cooperation. If universities achieved the goal of some of their members and staffs of eliminating the SBIR program, they stand to gain only about \$1 billion in annual funding out of a total of about \$65 billion. If it all was added to the university portion of about \$27 billion, it would add a little less than four percent to their current base. And the battle would be bloody, with little advancement of the truth.

Conversely, a consortium of the universities, small businesses, large businesses and federal laboratories would represent a formidable team in the presentation of the value of increased federal funding of research and development. It would take an increase of only 1.5 percent of the total federal funding of \$65 billion to achieve the \$1 billion re-apportionment of the SBIR program. Surely this is a better objective for our researchers in all sectors of the community.

The unique and powerful advantage for the United States' economic future is the technology continuum of:

- Research universities with their world-class education and research components,
- Federal laboratories with their support of technology development and research,
- Small businesses with their entrepreneurial successes second to none in the world, and,
- Large businesses with their global financial and market clout.

Demonstrating the value of this entire continuum is not only a more noble task than trying to position one group at the expense of the other—it is a much easier job. Congress and the public would be much better served by our research community by clear, objective communication of our overall national goals and strategies. The competition should be identified in the global arena, not in our national research community.

The problem with the federal R&D funding curve in Figure 5 is not with the allocation—it is with the stagnation of the growth. Together we have a chance to communicate the importance of changing the slope of the curve to a solid positive growth.

MIT and Route 128, Stanford and Silicon Valley, and UCSD and the San Diego technology clusters demonstrate the mutual benefits of close cooperation between the academic and entrepreneurial communities. Clearly, they have shown that the academic institutions are strengthened by collaboration with local small businesses. More importantly, they have demonstrated that these collaborative efforts are also beneficial to the national research agenda and the country's economic strength.

Critique and dialogue on the proposals presented are encouraged by the author.