CHAPTER 3

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## Summary


Colleges and universities play two very important roles in technological innovation and regional economic development. First, they play a central role in training scientists and engineers and expanding the base of scientific and technical knowledge. Second, by transferring this talent and information to the private sector, they provide a vital nucleus for the diffusion of innovation to existing firms and the creation of new businesses and industries. Although cooperation between the educational and industrial sectors is not a new phenomenon, the growing economic importance of technological innovation has created a greater need, and new opportunities, for cooperation.

The university sector has developed several types of programs to carry out these roles, including:

- *research and science parks,* clusters of research-intensive firms and facilities on a site near a university;
- *research and technical centers* that disseminate information, provide technical assistance, and perform short- or long-term research for local businesses in exchange for fees and other support;
- *university/industry collaboration,* including cooperative research ventures and research consortia;
- *entrepreneurship training and assistance,* including courses, seminars, and internships; technical and management advice; and incubator facilities dedicated to nurturing new ventures by students and local entrepreneurs; and
- *direct and indirect investment,* usually from endowment funds, in spinoffs, venture capital partnerships, and seed capital funds.

These programs bring financial rewards to universities at a time when many are experiencing a drop in student enrollment, a shortage of qualified faculty, and a decline in Federal support for research and development (R&D). The private sector, recognizing the importance of new knowledge and trained personnel to further innovation, is providing financial and technical support for university-based research centers, as well as grants for special research projects and assistance to precollege technical education. State governments, which have traditionally had a close relationship with higher education (two-thirds of U.S. Ph. D.-granting institutions are publicly supported), also are expanding their support for university-based initiatives because of the need for a well-educated work force and the recognition that the growth of high-technology complexes is closely linked to the presence of research-oriented educational institutions. The Federal Government's involvement in the development of university programs has been primarily indirect, usually taking the form of research contracts and grants; but the presence of a Federal facility may in itself be enough to attract other tenants to a university research park.

Collaboration at various levels offers solutions to several crucial needs of both universities and high-technology industries. Given strong leadership and sustained commitment, as well as stable sources of long-term funding, these initiatives and the cooperation they foster could contribute to industrial innovation and regional economic development by:

- reorienting university research toward the needs and interests of industry;
- increasing the speed with which research results become available to industry;
- allowing wider and more efficient use of university facilities, equipment, and personnel;
- improving the quality of training for scientists and engineers;
- attracting high-technology firms and encouraging the creation of new businesses; and
- improving the productivity and competitiveness of businesses already in the region.

These new developments involve difficult institutional changes, and it is too soon to determine their long-term effect on the creation and growth of high-technology businesses. While *existing* high-technology firms consider local educational resources and technically trained personnel in their decision to locate or relocate operations, the exact relationship between university initiatives and the creation of

*new* high-technology businesses is not fully understood. These programs may have less impact on the development of new technologies than on developing better relations with and services to existing businesses. Several of the programs identified in this chapter could be transferred to almost any university center, although the nature of the program will depend on the character of the university and the needs of local industry.

# Introduction

Colleges and universities play two very important roles in technological innovation and its diffusion through the economy.[1] First, they play a central role in preparing scientists and in expanding the base of scientific and technical information. Second, by transferring this talent and information to the private sector, they foster the commercialization and diffusion of innovation.

Cooperation between the educational sector and industrial sectors is not a new phenomenon—Stanford Industrial Park dates from the 1940's and Research Triangle Park from the 1950's. However, the growing economic importance of technological innovation has created a greater need for cooperation. Recognizing this, universities, industry, and State governments have responded by developing programs to mobilize the resources of the educational sector for local economic development. These efforts address not only the preparation of students but also the needs of new and expanding high-technology businesses, particularly the need for increased R&D and technology transfer and the need to provide technical/vocational skills to the local work force.

These programs bring financial rewards to universities at a time when many of them are experiencing a drop in student enrollment and a decline in Federal support of R&D. Ironically, it has often been the university sector that suffers from the apparent "shortage" of qualified engineering and science professionals. Industry can offer higher salaries and more modern facilities, which could attract faculty into industrial research and management and students away from graduate study. Industry is sensitive to this problem, and both groups have begun to search for solutions.

As the growth of Government R&D funding has slowed in the face of inflation and budgetary pressures, the education sector has become more active in soliciting funds from industry. In the 1980-81 academic year, according to the National Science Foundation (NSF), colleges and universities reported $778 million in voluntary donations from corporations.[2] This business support takes the form of grants, fellowships, or fees, and it is motivated by the need for trained technical staff and early access to basic research results. NSF surveys also show that two-thirds of all academic engineers now do paid consulting, compared to only one-third of their counterparts in the physical and biological sciences.[3] The private sector also is collaborating with State and local governments to improve the quality of math and science education, and to provide training, retraining, and employment development.

A study by the U.S. General Accounting Office (GAO) concludes that these developing linkages between university and industry can not only enhance technological innovation but can also stimulate regional economic development.[4] Research and science parks affiliated with universities attract new high-technology firms to their areas, and they also provide excellent seedbeds for spinoff companies. Technical centers and industrial extension services benefit existing local businesses by increasing the rate of innovation diffusion and increasing their access to facilities, equipment, and expertise. Coop-

[1] The material in this chapter draws heavily on the following documents: U.S. General Accounting Office, *The Federal Role in Fostering University/Industry Cooperation,* GAO/PAD 83-22, May 1983; National Science Foundation, *University/Industry Research Relationships: Myths, Realities and Potentials,* NSB 82-1, October 1982; "Universities Emerge as an Important Catalyst in the New Business Development Process," *Venture Capital Journal,* vol. 23, No. 8, August 1983, pp. 7-12; and National Governors' Association Task Force on Technological Innovation, *Technology and Growth: State Initiatives in Technological Innovation,* October 1983.

[2] National Science Foundation, op. cit., p.10.
[3] National science Foundation, op. cit., p.11.
[4] General Accounting Office, op. cit., pp. 15, 24, 40, 47-48.

erative research activities provide industry with early access to the results of university research and improved training for scientific and engineering personnel.

While stronger links between the university sector and industry might enhance technological innovation, institutional differences can make such cooperation and collaboration difficult. According to the GAO study:

> To realize their full potential, cooperative arrangements between universities and industry must reconcile long-standing differences . . . in [the] research objectives, management philosophies, organizations, and reward structures of the two sectors.[5]

The most fundamental of these differences is the question of research philosophy. The traditional role of the university is to educate and conduct basic research, but cooperative ventures give the university a proprietary interest in the results of research. The university, traditionally the trustee of the "public good" of basic knowledge, could now own and license information it used to provide freely. In addition, proprietary concerns may restrict the flow of information between individual scientists, the lifeblood of basic research. Several of the newest contract agreements between industry and universities reflect possible solutions to these problems, including the right of individual university researchers to publish their findings.

A second problem is the ownership of intellectual property, the main product of research. The ownership of this property is of primary concern to the universities, their faculty, and the supporting industries. Universities are examining their policies in light of the increased patentability of university-conducted applied research, and several of the most active research universities are interested in retaining their rights and commercializing products themselves.

This chapter identifies a cross section of university-related high-technology development (HTD) initiatives, discusses the problems they may create, and identifies some of the factors and conditions that may contribute to their success.

[5]General Accounting Office, op. cit. ! p.10

# University-Based Programs

University initiatives in industrial R&D are driven in part by the need to diversify funding sources, retain faculty, and attract students. However, changing technological and economic conditions have also led to a greater emphasis on commercializing research results, particularly when the university has royalty rights; on providing assistance to small businesses, particularly those started by faculty or students; and on cooperating more closely with State and local governments in economic development.

The university initiatives described below, which address specific business needs that can be served by university resources, fall into five general categories:

- *research and science parks,* clusters of research-intensive firms and facilities on a site near a university;
- *research and tehnical centers* that disseminate information, provide technical assistance, and perform short- or long-term research for local businesses in exchange for fees and other support;
- *university/industry collaboration,* including cooperative research ventures and research consortia;
- *entrepreneurship training and assistance,* including courses and internships, technical and management advice, and incubator facilities dedicated to nurturing new ventures by students and local entrepreneurs; and
- *direct and indirect investment,* usually from endowment funds, in spinoffs; venture capital partnerships, and seed capital funds.

## Research and Science Parks

An increasingly popular economic development initiative is the research or science park, on or adjacent to a university campus. Such parks general-

ly are composed of clusters of research-intensive firms and facilities on dedicated sites. They are often encouraged by State or local tax incentives, but many universities have also seen the advantage of encouraging this type of development.

Four basic benefits can result from locating a research or science park near a university. First, increased interaction and easier communication between university and industry researchers helps to broaden the mutual understanding of problems and needs. Second, business gains quicker access to new developments through increased information and knowledge transfer. Third, business also gains access to student workers and faculty consultants, as well as laboratory, computer, library, and other resources. Finally, the increased interaction opens opportunities for creating new businesses and new university/industry programs.

- The Stanford Research Park in California is often cited as the model for university/industry science parks. So is the Research Triangle Park in North Carolina, although it was originally a State government initiative. A more recent example of this initiative is at Washington State University, which recently established a research and industrial park to provide consulting opportunities for faculty, employment opportunities for students, and enhanced research finding for the university. The University of Utah has a science park specializing in biomedical R&D. Rensselaer Polytechnic Institute, a leader in university/industry cooperation, has a new high-technology industrial park 15 minutes from campus. The University of Illinois is working with the State to set up a high-technology research park on land donated by the city of Chicago. Similar efforts are underway in Florida, Michigan, New Jersey, Connecticut, and several other States.

## Research and Technical Centers

University-based research centers perform applied research in exchange for fees and other support, allowing firms to pool their resources to support long-term research of shared interest. The firms can thereby avoid duplicating expenses for facilities and equipment, and they also gain access to relatively inexpensive student labor. At the same time, the university benefits from the fees and increased research activities and from improved student training. The concentration of technical know-how, and often the availability of capital and business experience, makes these research centers fertile ground for the creation of new high-technology businesses. Because they also have been cited as a major factor in the development of high-technology complexes, a number of States have begun to encourage the development of of such centers.

- Examples of such research centers include the Microelectronics Center of North Carolina, the Center for Applied Microelectronics at the University of Wisconsin, and the California MICRO research center. The Surface Science Center at the University of Pittsburgh will provide basic and applied research results applicable to industrial technologies, and the University of Wyoming has set up an Industrial Fund to provide applied research to area businesses.
- The University of Minnesota's Microelectronics and Information Sciences Center (MEIS) was formed in 1979 with initial finding of $6 million from Control Data, Honeywell, 3M, and Sperry. It utilizes the facilities of the corporate participants in order to minimize laboratory investment and has already attracted almost $1.5 million in Federal research awards. MEIS received $1.5 million in 1983 from the State legislature, which is also considering a proposal to create a Supercomputer Institute at the University of Minnesota.

Several universities have also set up special offices or technical centers to provide short-term technical assistance to local businesses, including patent searches, technical staff, and other research services. Rather than establishing long-term research agenda, these centers tend to emphasize technology transfer and consulting services. In some ways, they can be viewed as applying the Agricultural Extension Service model to nonagricultural industries. Such centers can be particularly helpful in communities with fragmented industrial bases where firms are unable to pool their resources effectively.

- The Center for Industrial Cooperation at the State University of New York at Stony Brook, for example, provides research and technical assistance on specific industry projects for 15 dues-paying industrial affiliates. Another technical center is the George Mason Institute at George Mason University in Virginia, which provides technical

assistance to high-technology business and education groups in the State. The Delaware Technical and Community College (with funding from the U.S. Economic Development Administration) is setting up a similar center to work with technology-based businesses in Delaware; the school is also working with General Motors to develop a joint training and retraining program for auto workers. The University of Missouri also is working closely with the auto industry to train and retrain workers for the new technical demands of automated manufacturing. The New Enterprise Institute at the University of Southern Maine helped to introduce computer-aided design and manufacturing to Maine's shoe and leather industry. Finally, the University of Wisconsin has an Industry Research Program that provides business with information on the results of its research.

## University/Industry Collaboration

In addition to providing funds for research activities, high-technology firms are beginning to participate more directly in university research initiatives. (See ch. 5 for a discussion of this and other private sector initiatives.) Several university/industry research partnerships have been formed to match the special technical needs of high-technology industry and the unique resources of the educational sector. The two most common forms of cooperative ventures are joint ventures between a university and a single firm, and research "consortia" involving several companies and/or universities. Such arrangements can take many legal forms, including long-term research contracts and limited partnerships.

Recent legislation enables industrial partners to obtain tax credits for investments in university research, in addition to capital gains treatment for profits on the products of the research. However, not all of the problems created by jointly owned intellectual property have been resolved. In the past, universities have preferred to receive grants to conduct independent research, rather than joint ownership of discoveries developed with industry technical personnel and equipment. However, shortages of technical personnel in some fields, as well as the cost of facilities and operations, have made it necessary—and in some cases, financially attractive—to share research staff and equipment.

Cooperative Research Ventures. -Although several substantial ventures have been launched in the last few years, university/industry cooperative research ventures still represent a very small portion of university research. Most universities appear to be waiting to see the results before attempting a venture of their own. The most visible and substantial agreements have been signed between Harvard University and Monsanto; Washington University and Mallinckrodt; Harvard Medical School and Seagrams; Massachusetts Institute of Technology (MIT) and Exxon; Carnegie-Mellon and Westinghouse; and most recently, Washington University and Monsanto.

- The Washington University-Monsanto agreement reflects awareness of some of the common problems experienced by previous agreements. The 1982 grant of $3 million will eventually grow to $7 million per year, or about 5 percent of the Monsanto research budget. The agreement is institutional in that it avoids a direct relationship with any individual faculty member. It provides for the review of research requests through a system of peer review by scientists from both organizations. Research will be conducted in basic science areas in which the organizations report complementary expertise; the first research project will focus on proteins and peptide cellular function. The university will hold the patents on any invention that emerges from the research, with the royalties accruing to the department responsible for developing it. Monsanto will have exclusive licensing rights to such patents, but faculty members will be free to publish their research results.

Research Consortia.—This type of program may include either one company and several universities, several companies and one university, or several companies and several universities. An example is the research center at Purdue University in Indiana, jointly sponsored by five corporations, to develop computer prototypes. Similarly, Pennsylvania State University has 20 sponsoring industries for a cooperative program in recombinant-DNA technology. Other examples include the Cal Tech Silicon Systems Project, Stanford's Center for Integrated Systems, the Polymer Affiliates Program at Drexel University, and (perhaps the most complicated example) the Center for Biotechnology Research.

Ž The Center for Biotechnology Research is sponsored by Engenics Corp. (itself a Stanford spin-off) along with six other companies: Bendix, Elf Technologies, General Foods, Kopvenco, Mead, and MacLaren. Three universities are involved: Stanford, the University of California, and MIT. Resulting patents will be held by the universities, with the center receiving royalties, and the contributing corporations having exclusive rights to the patent licenses. The object of the center is to provide multiyear funding for university research and to enhance the effectiveness and efficiency of basic and applied research. It will also allow universities to benefit from a prodct's financial success, as well as providing industry with incentives to justify long-term research investments.

## Entrepreneurship Training and Assistance

Universities have also become more active in training entrepreneurs and supporting their efforts to create new technology-based enterprises. The number of colleges and universities offering entrepreneurship courses grew from less than 10 in 1960 to over 200 in 1980 and has doubled since then.[6] In some cases these programs are supported by the private sector, which sees in them an opportunity to promote the values of capitalism as well as the university's role in entrepreneurship education and technological innovation.

- The University of Texas, for example, has not only a Chair of Free Enterprise (established in 1976) but also an Institute for Constructive Capitalism, funded by Mobil, Shell, Tenneco, and other corporations. Similarly, two leading venture capitalists have recently endowed a chair at the Harvard Business School devoted to the creation and management of new business ventures.
- The Center for Entrepreneurship and Small Business Management at Wichita State University, established in 1977, is supported by over 50 local businesses.

Several universities have also established special internships or degree programs designed to provide students with practical experience in technology-based businesses. Lehigh University in Pennsylvania, for example, has a cooperative master's and Ph. D. program directed toward students employed in industry. The students' graduate work is a combination of professional work (directed by industry advisors) and university study and research conducted in cooperation with professional work. Similar programs exist at Carnegie-Mellon University, the University of Detroit, and other universities and colleges.

In addition to courses for full-time students, many universities also provide seminars and conferences on business development topics, notably how to raise venture capital, or provide technical and management assistance to local entrepreneurs and inventors. Baylor and Case Western Reserve, among other universities, provide innovation evaluation programs in addition to courses and seminars. Carnegie-Mellon and the University of Pittsburgh jointly sponsor the Pittsburgh Enterprise Corp. to foster new business development. These efforts are notable for their success in involving local professionals–lawyers, accountants, bankers, consultants, and government officials-as well as university officials in supporting and securing funding for local entrepreneurs. The MIT Enterprise Forum, sponsored by the alumni association, conducts "incubator forums" in several cities.

Finally, several universities have established "incubator" facilities to make their resources available to new businesses or entrepreneurs developing a new product or process. Such a center recognizes and formalizes the university's role as a seedbed for new technologies and new technology-based companies. This approach incorporates and exploits several resources of the university, including low-cost office and laboratory space, as well as access to capital, business planning, and management advice from faculty members and local professionals. While some of these centers extend eligibility to qualifying small business, their emphasis is on the enterprising student or faculty member who needs a head start in commercializing a promising innovation.

- The oldest such facility is the University City Science Center in Philadelphia, founded by 23 colleges and universities in 1967, but similar centers exist at Rensselaer Polytechnic Institute, Georgia Tech, Carnegie-Mellon, MIT, Wichita State, and the University of Missouri.

[6] *Venture Capital Journal,* op cit., p. 8.

The Utah Innovation Center, set up by the University with an NSF grant in 1978, has continued as a private concern following the loss of its Federal funding.

### Direct and Indirect Investment

In addition to their efforts to promote new linkages with industry, many colleges and universities have begun to take a more active role in financing new technology-based companies. ' These investments are usually made from the university's endowment or alumni fund, with capital gains rather than new business development as the object.

In some cases, they invest directly in companies that have spun off from research and technical centers. Examples include Boston, Harvard, Lawrence, and Stanford Universities; the Universities of Chicago, Notre Dame, and Rochester; Rensselaer Polytechnic Institute; and Grinnell College in Iowa. Brown University recently acquired a major interest in a spinoff in return for its contribution of technology.

In other cases universities work to make capital available to new starts by investing in venture capital partnerships. About $350 million has been invested in such partnerships, most of it since 1980, by universities such as Carnegie-Mellon, Harvard, MIT, Stanford, and Yale. Michigan Tech has just formed the first university-based Small Business Investment Corporation, the Michigan Tech Capital Corp. Other universities (including Carnegie-Mellon, Georgia Tech, Case Western Reserve, and the University of Pennsylvania's Wharton School) are supporting the formation of seed capital funds for early stage spinoffs, often in connection with their incubator facilities and entrepreneurship assistance programs (see above).

[7] *Venture Capital Journal*, op. cit., pp. 11-12.

## State Government Involvement

A number of State governments are working with their public universities to set up programs aimed at the stimulation of innovation and development. This includes the broader aims of encouraging engineering and science education, R&D on campus, precollege science and mathematics training, and technical skill training. State governments are ideally situated to encourage these efforts, according to the National Governors' Association Task Force on Technological Innovation:

> Of the *184* Ph. D, granting research universities of the United States, 119 are public institutions supported by State and local governments . . . [which] are the prime points of contact with respect to locational issues, labor relations . . . provision of capital . . . and other facets of economic activity that entail industry-government-education interaction.[8]

An example is Arizona's Center for Excellence in Engineering, a joint program sponsored by the State government and Arizona State University to improve engineering education and coordination of industry and university resources. Wayne State University in Michigan is the home of the new Metropolitan Center for High Technology, which will provide R&D, incubator space, and industrial training. Also in Michigan is the Innovation Center at the University of Michigan, which will help Michigan firms improve productivity by adopting new manufacturing technologies. Similar initiatives are underway in several other States:

- The Illinois Legislature provides part of the funding for FRATS-Faculty Research Assistance to the State—which provides computerized information about faculty research capabilities to State business.
- The Florida Research and Development Commission is working closely with State universities to set up several research parks on campuses.
- Science Park, a cooperative venture among Yale, the State of Connecticut, and the Olin Corp., takes advantage of the Connecticut enterprise zone tax and trade incentives.

[8] Governors James Hunt of North Carolina and Dick Thornburgh of Pennsylvania, "To Our Fellow Governors," July 1983, p. iii.

- The Industrial Research Extension Center, located at the University of Arkansas at Little Rock, provides information on technical issues to both the public and private sectors.
- The Mississippi Board of Higher Education has a similar program at the Mississippi Research and Development Center. This program provides information about technology issues to the State Legislature while aiding in technology transfer between State universities and industry.
- Both the University of West Virginia and University of Kansas have State funding for a center for entrepreneurship. They provide both students and local entrepreneurs with the management and technical information needed to commercialize an idea.

A number of community and junior colleges are working with their State, local government, or local industry to provide training in technical skills needed by high- technology industry. In some cases, these programs take the form of a general training course; in others, these institutions work directly with a local firm to train the labor needed for expansion. An example of this is the Albuquerque Vocational-Technical Institute's Laser/Electro-Optics Technicians Program, which not only trains students in this high-technology field and helps them find jobs, but also helps local firms with R&D and assists them in manufacturing implementation and product inspection.

State and Federal agencies have provided support for such research cooperatives. Stanford University will be the location for an innovative cooperative effort called the Center for Integrated Systems, in which 20 industrial cosponsors are cooperating with the Federal and State governments to fund the development of an "umbrella" facility for R&D.

# Conditions That Foster Success

The barriers to improved collaboration between university and industry include the sectors' different objectives, values, reward structures, attitudes, and research agendas. The examples cited above demonstrate that these barriers are not insurmountable, or at least can be worked out to the extent necessary for any particular effort. GAO listed the following factors as essential to resolving such issues for successful collaborative arrangements:

- *commitment by both faculty and administrators* at a university to the concept of orienting some portion of university research and expertise toward industrial research;
- commitment *by* participating firms to explore and utilize the strengths of the university while simultaneously honoring university objectives;
- *flexibility in the university* to allow policies and organizational developments for interaction that are responsive to industrial objectives but do not compromise the academic mission of the university;
- *a strong leader* highly respected by both the academic and industrial communities to establish and maintain the partnership;
- *matching the needs, interests, and resources* (both physical and human) of both university and industrial partners; and
- *sustained sources of funding.*[9]

Many of these same factors, as will be seen in the following chapters, are also critical to the success of the public/private partnerships involved in industry and local government high-technology initiatives.

In addition to the above conditions, specific factors are also important for the success of different types of university-based initiatives. Efforts are not likely to be successful unless the needs and resources of the participating firms and universities are matched. GAO points out, for example:

> Research parks work best at first-tier research universities where a significant proportion of administrators and faculty favor interaction with industry. Industrial participants most likely to benefit from this arrangement are high-technology firms that depend strongly on technological innovation for their success.

[9]General Accounting Office, OP. cit., p. 50.

Cooperative research centers require a university with strong departments in areas relevant to the focus of the center. Industrial participation is most successful with medium to large-sized firms which have their own research and development capacities adequate to translate the research results into commercial technological applications.

Industrial extension services are best performed by a university with a strong commitment to community service and a technology focus to assist local, fragmented industrial clients.[17]

[10]General Accounting Office, op. cit., p. 50.