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BEST PRACTICES AND KEY SUCCESS FACTORS IN INDUSTRY-ACADEMIA-GOVERNMENT COOPERATION AND REGIONAL INNOVATION IN THE U.S.

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Abstract

Both the United States and Japan have government programs to promote industry-university research and technology transfer. For example, the U.S. supports university-industry engineering research centers and uses the Bayh-Dole Act to encourage the transfer of university research to companies. Japan has similar policies.

However, in a related policy area – the promotion of regional innovation and economic growth – the U.S. and Japanese governments take different approaches. In Japan, the national government plays an important role, through such programs as Venture Business Laboratories and incubation facilities. The U.S. federal government has very few programs directly aimed at promoting regional innovation. Instead, the federal government contributes to regional economic growth *indirectly*, by supporting R&D at universities, companies, and federal laboratories; by buying high-tech products (and thus contributing to the demand for innovative products); and by maintaining tax laws, intellectual property rules, and other policies that encourage and reward entrepreneurship. Many state governments and local civic organizations seek to build on federally-funded R&D capabilities in their regions, in the hope that they can encourage the creation and growth of high-tech clusters. Some regions in the U.S. succeed better than others. The experience of San Diego, California, illustrates some best practices and key success factors in U.S. regional innovation.

Introduction

Both the United States and Japan have similar government policies and programs to encourage industry-university joint research and to promote technology transfer from academia to industry. However, in a related policy area – the promotion of regional innovation and growth – the U.S. and Japanese governments take different approaches. This paper summarizes these similarities and differences. It also examines one successful effort in the United States to promote high-tech regional development – San Diego, California – and uses this case to illustrate some best practices and key success factors in U.S. regional innovation.

U.S. and Japanese Policies to Encourage Joint Research and Technology Transfer

In the late 1970s and throughout the 1980s, U.S. policy-makers searched for ways to make federally-funded research and technology more useful to American companies. During this era, Japanese companies were performing very well in sectors ranging from automobiles to semiconductors and supercomputers. The U.S. continued to do well in basic scientific and technological research, but concerns grew about U.S. problems with commercialization and industrial competitiveness. U.S. Senator Ernest Hollings stated America's problem this way: "The U.S. gets the Nobel Prizes, and the Japanese get the profits." He meant that statement as both a compliment to Japan and a criticism of the United States.

The analysis at the time argued that universities, companies, and government laboratories did not cooperate enough with each other, due to legal and institutional barriers, and that this lack of cooperation slowed the pace of commercialization. In particular, policy analysts and policy entrepreneurs focused on three sets of barriers: those limiting or slowing cooperation between universities and companies, barriers between federal laboratories and companies, and barriers that prevented joint research and development (R&D) among companies.

The federal government adopted three major policy initiatives designed to facilitate and encourage university-industry cooperation: the Bayh-Dole Act (more formally known as the Patent and Trademark Amendments of 1980); the research and experimentation tax credit (1981); and two sets of center sponsored by the National Science Foundation (NSF), industry-university cooperative research centers and engineering research centers. Other initiatives aimed to improve cooperation between federal laboratories and companies (the Stevenson-Wydler Technology Innovation Act of 1980 and the Federal Technology Transfer Act of 1986), and to allow companies to enter into joint R&D ventures (the National Cooperative Research Act of 1984).

The new laws came at a time when U.S. companies and universities both wanted to expand R&D cooperation and technology transfer. In the 1980s and into the 1990s, large American companies showed new interest in external sources of technology, both because (1) intense global competition led them to cut internal R&D spending, and (2) as technologies became increasingly complex, companies found it harder and harder to maintain all necessary capabilities internally. Companies saw academia as one promising source of valuable external research. For their part, universities had small but growing numbers of professors who wanted to become high-tech entrepreneurs, and university administrators liked the idea of attracting corporate money through joint research and patent licensing. So Bayh-Dole, engineering research centers, and the other initiatives came at a time when many companies and universities were interested in partnerships.

Today, university-industry research partnerships and technology transfer are major features of American science and technology. Companies now fund approximately six percent of university R&D in the United States (in 2002, $2.3 billion out of $36.0 billion). This amount is still low as compared with government funding but still higher than in recent decades. Moreover, at least a few companies, such as Cisco Systems, now see universities as their "research laboratories," using contracts with professors instead of maintaining their own in-house labs to generate new research.

The federal programs that encourage and support joint university-industry research also are continuing:

- Today NSF supports 22 engineering research centers. Another 16 centers, established in earlier years, are now self-sufficient.

- NSF also now supports 49 additional centers through the Industry-University Cooperative Research Centers Program.

- NSF has begun to fund Nanoscale Science and Engineering Centers, which also have industry participation.

Technology transfer is also much higher than in earlier decades. The Association of University Technology Managers (AUTM, www.autm.net) – a group of university technology licensing offices – provides the following statistics in its 2002 annual report:

- In U.S. fiscal year 2002, universities issued 4,673 new licenses, bringing the total number of active licenses from universities to 26,086.

- In 2002, U.S. universities reporting to AUTM received $1.267 billion in royalty income.

- In 2002, the U.S. had 450 new start-up companies based on university licenses. There have been a total of 4,320 new firms based on university licenses since 1980 (although of course not all of those companies still exist).

In addition to joint research projects and formal licenses, universities also contribute to companies in other ways, including through faculty consulting and the training of students who go to work in companies.

Japan, of course, has similar policies and programs to encourage and support R&D cooperation between academia and industry. The policies and programs include a law similar to Bayh-Dole, the technology licensing offices, and matching funds to promote joint research between industry and universities. Today's presentation by SAITO Naoki of NISTEP provides details on these important initiatives.

In both countries, government policies and programs have succeeded in promoting greater R&D cooperation and technology licensing. Key success factors and best practices in the United States include the following:

- Firms want access to high-quality researchers and research products, and they prefer to work with universities whose officials are "user-friendly" – that is, officials who do not make negotiations or projects difficult for the companies. Companies particularly want to work with universities that hire very good faculty and attract high levels of federal funding.

- Universities with medical schools and very good biology departments are the most successful in licensing technologies and earning royalties. Patents are important to biotechnology companies, and they are willing to pay for valuable licenses. A few universities also make money by licensing information technology patents – although in the U.S. patents are less valuable in the IT industry than in biomedicine. Universities without strong biomedical or IT departments usually do little licensing, and their royalties may not even pay for the cost of operating a university technology transfer office.

- Universities are more likely to generate start-up companies if they (1) have flexible personnel policies that allow professors to take time off to start firms or advise new companies, and (2) have what we call "second-generation" technology licensing offices. The first generation of offices often believed that their mission was to raise as much royalty income as possible. By trying to negotiate for as much money as possible, they sometimes alienated both companies and professors. "Second-generation" licensing offices believe that their mission to help build companies, including companies started by professors. They are more "user-friendly."

U.S. and Japanese Government Policies to Encourage Regional Innovation

While government policies to encourage university-industry R&D and technology transfer are similar in the United States and Japan, government policies in a related area – the promotion of regional innovation – are different in the two countries. The Japanese national government has significant programs to help regions improve the technology of existing industrial clusters and to help create new technology-based clusters. The United States, on the other hand, has few federal government programs that directly promote regional innovation. In America, regional economic development is seen as the responsibility of state and local governments, not Washington, DC. However, the federal government does play an important *indirect* role in promoting some regional innovation.

Government programs – whether from national, state/prefectural, or local governments – can play an important role in promoting regional innovation. This is because regional innovation capabilities can, to a large degree, be created. One does not want to over-state this point: all regions face constraints that limit what they can accomplish, and even well-designed and well-funded initiatives can fail because of conditions beyond their control. And of course some regions have better assets than others. For example, some regions have strong existing industries, a skilled local workforce, and a climate and culture that attract entrepreneurs and skilled professionals. Even so, a wide variety of American regions have recently tried to grow new high-tech clusters (as well as strengthen their existing, older industrial clusters). What have we learned from these experiences, and how are American approaches similar to and different from those in Japan?

Japan's programs to promote regional innovation include several initiatives to aid university-initiated startups, including the Venture Business Laboratories, Technology Transfer Facilitation Programs, funding for incubators, and NEDO subsidies and grants. Japanese ministries also have other programs to help regional industries, including METI's Industrial Cluster Plan. Again, the presentation today by SAITO Naoki provides details on these important initiatives.

By contrast, the U.S. federal government has only a few programs that *directly* aid specific regions. These programs include the following:

The U.S. Economic Development Administration (EDA), a part of the U.S. Department of Commerce, provides planning grants and infrastructure development grants (for airports, etc.) to "distressed regions" – regions that are poor or that have experienced serious economic problems. In recent years, EDA has become more interested in the potential of technology-based industries to help these regions, but it is not a significant player in U.S. high-tech development.

There is also an Appalachian Regional Commission that helps the largely impoverished states along the Appalachian Mountains, in the eastern and southeastern United States.

The Commerce Department also supports a national network of centers to assist small manufacturers, a network known as the Manufacturing Extension Partnership (MEP). It is not an economic development program, but it does help existing manufacturing clusters improve their technology and competitiveness.

A small program sponsored by the National Science Foundation (NSF) helps states that historically have received little federal R&D funding to improve their universities and linkages to local industry. This initiative is the Experimental

Program to Stimulate Competitive Research (EPSCoR). Small versions of this program also exist in several other U.S. departments.

In recent years, the most significant federal "program" to help university-based economic development in American regions has been a series of individual projects for individual regions provided by Senators and Members of the U.S. House of Representatives. We call these projects "earmarks" – special set-asides in agency budgets for specific universities and other organizations. This is a modern version of an old idea, called "pork-barrel politics," in which Members of Congress send federal money to their particular regions. The quality of these projects can be very low.

Despite these programs, the U.S. Government does relatively little *directly* to aid specific regions of America. However, the policies and programs that *indirectly* aid U.S. regions are significant and often very helpful. By "indirect" we mean that these federal initiatives that are not aimed at specific regions and that are not designed primarily as economic development tools. Instead, they designed to meet national needs but contract with universities and companies in regions across the nation. Three sets of federal government policies and programs are particularly important in the United States.

Federal R&D funding to universities and companies. The U.S. annual R&D investment is huge – over $125 billion in federal fiscal year 2004. While much of that is for the development of Defense Department weapons, some $55.5 billion is for basic and applied research in science and technology. Research organizations around the country compete for this money. Those organizations that compete successfully tend to attract the best researchers, some of whom make important contributions to either existing companies or new startup firms. Economic studies in the U.S. suggest that regions with high concentrations of the best federally-funded scientists do particularly well in new research-based industries, such as biotechnology. In short, if a region attracts world-class researchers and wins significant federal research money, that region has major resources for developing and sustaining high-tech industries. In addition, the U.S. Government has several R&D programs that help companies develop new basic technologies: the Small Business Innovation Research (SBIR) Program, which exists at several federal departments and agencies and helps small entrepreneurs; the Advanced Technology Program (ATP), which helps both small and large firms develop new economically-important technologies; and awards from the Defense Advanced Research Projects Agency (DARPA). Some regions do particularly well in winning these R&D awards.

Federal procurement of high-tech products. Since the early twentieth century, the U.S. Government has often been the first to buy new high-tech products. A company or region that succeeds in selling to the Defense Department and other government agencies does not necessarily also succeed in commercial markets. However, Boston and California's Silicon Valley are two examples of regions whose early electronics industries grew largely by selling to the government.

Intel, for example, first sold its integrated circuits to the U.S. Air Force. Later these companies in Massachusetts and California also became successful in the commercial world.

Federal laws that encourage and help high-tech entrepreneurs. These laws include Bayh-Dole, laws to protect intellectual property, and federal tax laws that enable successful entrepreneurs to become rich. Again, these laws apply in all regions of the United States, but some regions are particularly able to take advantage of them and develop their high-tech industries.

In the United States, state and local governments and local business groups have primary responsibility for trying to strengthen regional innovation. State and local leaders will try to build on regional assets both to strengthen existing industries and to try to grow new ones. If a region already has succeeded in attracting federal R&D funding or federal procurement contracts or both, then that region has a major advantage. Other major assets include a skilled workforce, an attractive local climate, and an attractive local culture – all elements that entrepreneurs and other business leaders like.

There is no "recipe" or "cookbook" for how to create innovative and successful regions. However, the U.S. experience suggests that *people* are a region's most important asset. A successful region attracts, supports, and retains good people and their companies. This factor is particularly important when trying to build new high-tech clusters. When building high-tech clusters in a region, three communities of people are particularly important:

A community of technology leaders. If a region has – or can create – world-class research universities and other research organizations, then it can attract world-class researchers. Some of them – with the right local business support – will become entrepreneurs or scientific advisors to new companies. The region may then attract other entrepreneurs, including business executives who started with the region's early companies and then go on to establish newer firms.

A "social infrastructure" to help entrepreneurs. Both first-time entrepreneurs and even experienced entrepreneurs need help. To start their companies, they need money (venture capital, etc.), skilled lawyers and accountants, and sometimes mentoring. In short, a region needs a community of experts who can help entrepreneurs (and existing, larger companies) organize and operate. Established high-tech regions already have this kind of "business support infrastructure." Regions that are trying to start new high-tech clusters can create social networking organizations and deliberately try to build a regional support infrastructure.

Skilled professionals. Once a region begins to grow a few entrepreneurial firms, the most important problem is frequently finding skilled business professionals to staff these firms. New companies and new clusters need researchers, engineers, and skilled business managers in fields such as finance, operations, and marketing.

> A region that has good local engineering and business schools can develop local talent, or companies can try to "import" skilled people from other regions of the United States or the world.

One Example of Best Practices: San Diego, California

Several regions of the United States have successfully created or expanded their local high-tech industrial clusters. Examples include the Research Triangle area of North Carolina; Austin, Texas; Seattle, Washington; and San Diego, California.

An element of luck always exists in these stories. For instance, Bill Gates chose Seattle rather than someplace else to start Microsoft. Silicon Valley's semiconductor industry began mainly because one researcher, William Shockley, decided to build his new company in Palo Alto instead of Boston.

But in many cases, local business, educational, and government leaders also deliberately tried to build up their regional assets and attract skilled researchers and important high-tech organizations. Austin, Texas, for instance, made a sustained effort in the 1980s to improve the science and engineering departments at the University of Texas, Austin, and then successfully recruited Sematech, an important technology development organization.

San Diego, California, is one of the most notable U.S. examples of a region that deliberately tried to build its regional innovation. Here, too, elements of luck were important. But the region employed what many analysts considered to be a very sophisticated strategy. That strategy developed over many years, but it eventually covered all three of the key elements listed above.

Technology leaders. San Diego has long had several major industries: aircraft and missile manufacturing (now largely gone), tourism, and several bases for the United States Navy and U.S. Marine Corps. But the high-tech story for commercial companies begins with several research organizations. In the 1960s, local leaders persuaded the University of California to expand its existing UC marine science laboratory, the Scripps Institution of Oceanography, into a full UC campus, the University of California at San Diego (UCSD). While local business leaders wanted a campus that would train engineers for the local aircraft industry, UCSD's early academic leaders wanted to create a world-class scientific research university. Originally, UCSD did not even have an engineering school (it does now). UCSD focused on the physical sciences and biomedical research. It quickly grew and began to attract top researchers and federal R&D funding. Two other non-profit research organizations also began in the 1960s, both in the biomedical area: the Salk Institute and the Scripps Research Institute.

The irony is that these research groups did not originally want to play a major role in local economic development. However, several of their professors decided in the late 1960s and in the 1970s to become pioneering entrepreneurs. Irwin Jacobs of UCSD, with his partner Andrew Viterbi of UCLA, created a digital wireless communications company called Linkabit to serve government clients. Linkabit's founders and executives went on to create an entire wireless communications industry in San Diego, now best known for another Jacobs-Viterbi company, Qualcomm. A UCSD medical professor, Ivor Royston, and a colleague started San Diego's first biotechnology company. San Diego is now one of America's leading biotech regions, and an example of how world-class research organizations can provide technology leaders for high-tech clusters.

Social networking and a business support infrastructure. Until the 1980s, most major government and business leaders in San Diego paid little attention to the new high-tech sectors. But in the 1980s and into the 1990s, some traditional San Diego industries shrank, including banking and especially defense aerospace. As local leaders looked around for possible new growth industries, they realized that high-tech – especially wireless communications and biotechnology but also software and later Internet companies – offered great potential. The problem, though, was how to grow a large number of high-tech companies in a region without its own venture capital industry, expert lawyers and accountants, or major engineering and business schools.

The solution in San Diego was to create a "social networking" organization that would link aspiring entrepreneurs and aspiring business support experts to each other and help them learn this new business. This organization, based at UCSD and called "Connect", also linked new entrepreneurs to outside venture capital firms. In the United States, informal social networks of the type Connect facilitated can build trust, understanding, expertise, and contacts. Observers in San Diego believe that Connect played a valuable role in accelerating business development in the region.

Skilled professionals. In the early years of San Diego's wireless and biotechnology industries, companies had to recruit skilled engineers and executives from outside the region. (The region did have a good supply of biomedical researchers, trained at local institutions.) As the new clusters expanded, regional leaders sought to create new local supplies of skilled people. For example, UCSD quickly developed special night courses to teach working engineers about wireless technology. Eventually, Dr. Jacobs and his wife funded the Jacobs School of Engineering at UCSD, to train additional engineers and a create a group of research professors. Similarly, UCSD provided some business courses (although campus leaders are still trying to get permission to create a business school). Other educational institutions in San Diego also helped, by training, for instance, laboratory technicians for the biotechnology industry.

All three of these elements – technology leaders, a community of business support services, and skilled professionals – have helped San Diego become a major high-tech center. Very good weather and an attractive, pro-entrepreneurs business culture also helped to attract and retain entrepreneurs. And like Silicon Valley, San Diego now has sufficient size and expertise to move successfully into entirely new, emerging areas such as bioinformatics and nanotechnology.

One should not exaggerate what San Diego has accomplished. The wireless telecommunications and biotechnology industries have created significant jobs, but the numbers are not huge. Moreover, these industries are subject to booms and busts. Nonetheless, at a time when many regions in the United States would like to create new industries and jobs, San Diego is a significant success.

Conclusion

What can the experiences in San Diego and other American regions tell us – particularly at a time when regions with both older industries and newer high-tech sectors face intense competition from China?

Older manufacturing regions without major research organizations face serious challenges. But many older regions do have good universities and other assets that they can build upon. They frequently start with what they do best. Pittsburgh, for example, draws heavily on its highly-regarded medical centers and the IT and robotics capabilities of Carnegie-Mellon University. Pittsburgh also has cleaned up many older neighborhoods and made itself into a more attractive city. Cleveland, an older city with many problems, is similarly trying to generate spin-off companies from the Cleveland Clinic and Case Western Reserve University. As mentioned earlier, Austin, Texas, is one city that has worked hard, and successfully, to improve its university, attract high-tech companies and research organizations, and create a pro-entrepreneur environment.

Above all, the American experience suggests four key success factors:

- Public and private investments in universities, other research organizations, and high-tech companies will attract and train technology leaders – leaders who can help keep existing companies competitive and who can start new firms and sometimes entirely new clusters.

- Regions that try to create high-tech clusters benefit enormously from organizations that give entrepreneurs social contacts, access to experts and resources, and mentoring. Regions that do not yet have communities of high-tech entrepreneurs and business support services can create organizations that will help build such communities.

- To grow, new high-tech clusters need skilled professionals: scientists, engineers, and business executives who can provide the skills growing companies need. Regions that want to grow economically need to provide such people.

- Finally, the U.S. system works because the overall culture and government policies support and encourage entrepreneurs.