CHART 7

	Convergence of indus/ univ interests	Public interest in high-tech growth	Shifts in traditional roles	New ideas have grown from univ setting	Small firms can piggy back univ facilities	State/Fed programs leverage indus dollar
Traditional roles of academe, industry	X	X	X	X		
Univs must balance teaching and research	X	X	X		X	
Modern research equip't is expensive		X			X	X
Univs cannot be leaders in all sci fields	X					
Proprietary data problem	X		X			
Antitrust threats inhibit more coop		X				
R&D tax credit: will it be renewed?		X				
#of US-born grad students in sci/eng is down		X				

The chart illustrates that paying attention to such incentives could go a long way in maximizing the benefits from closer industry-university relations. It also indicates that one of the largest perceived problems—lack of money—bears a close relation to several incentives and is where a national program for dealing with these issues might start.

The important aspect of industry-university relations is that closer ties are in the interest of several parties: the industrial firm (including the smaller, high-tech firm), the university, the State and local government, and the Federal Government. The cross fertilization of ideas that is important to the basic function of the university is also critically important to the continued development of basic and applied science. If this principle is not disturbed by government policies, it will rebound to the benefit of academia, U.S. industry, and the national economy.

Implications for Federal Policy

The technological sophistication of the United States today, which is due in large part to the impressive achievements of American scientists and researchers at universities, is being severally challenged by the rapid utilization of new technology by America's international trading partners. In many cases, foreign firms have gained a competitive advantage by paying better attention than American firms to new technologies and rapidly adopting them. This has been especially true with regard to advanced manufacturing technology, which is in more widespread use in Japan than in the United States.

This technological basis of industrial competitiveness has reemphasized the need for a better connection between basic research activities and commercial ones; between the university and the industrial researcher. Too close an alliance, however, may be detrimental. If a university cannot maintain its independence from an industrial sponsor, it becomes more and more like an industrial research department.

Experience has shown that the most constructive industry-university collaborations occur when there is a mutual understanding of the unique roles played by each party. This kind of understanding usually takes time, as it is personality-based and often depends upon a deep understanding of each party's motives and ways of doing business. Notwithstanding the difficulties involved in industry-university collaborations, the commonality of interest virtually requires a high degree of cooperation in order that the goals of both institutions be realized.

Federal Government policy, if misdirected, has a potential for frustrating these goals. This is because Washington has the power to redirect a substantial percentage of research resources, which are in fact limited. If this Federal direction does not accord with the overall national interest, the country could end up with a technology-short industrial base.

Legislation is often proposed that would have the Government take the lead in developing commercial technologies. Such legislation is motivated by the sincere belief that some technological areas are "leading" sectors, and key to U.S. industrial competitive-

ness. Bringing the Government in as a sponsor of basic and applied research in these areas could give America a critical technological edge on the rest of the world. It draws from what some people believe is the proper role of government: picking technological "winners" in the race for trade supremacy, and bringing government resources to bear on promoting these technologies.

Should the Government need such technologies as a consumer, such research can be useful. Indeed, this is done on a regular basis, through research contracts led by various agencies such as the Department of Energy, the National Aeronautics and Space Administration, and the Department of Defense.

The Federal Government, however, would be ill advised to attempt to create technology that may or may not be commercially useful. Experience has shown that government-induced demand often distorts market realities. The history of supersonic transport provides a conspicuous example, but numerous smaller ones exist as well.

The industry-university collaboration route to technology development takes another, more reliable, approach. In such a case, the demand for technology is being generated by the end user; industrial firms pick the winning technologies. Their choice may be mistaken in some instance, but it is always made with an aim toward the most efficient allocation of resources.

The United States has a unique system of housing basic research at universities and relying on industry to develop technology and new products from basic research. Within the American system, a rough division of labor has proven to be efficient. To a large extent, the health of basic research in the United States—and the lure of industry to academe—depends upon Federal Government funding for basic research at universities.

As stated, universities and industry have been developing new collaborative mechanisms to help spread the development and transfer of technology into the marketplace. While the primary force for the emerging role of academe is the increasing technological sophistication of the American economy, a number of important public policies have been encouraging and facilitating the trend. More generally, public policies that promote a more competitive economy, such as open trade policies and deregulation of domestic industries, by raising the need for commercial R&D to remain competitive, are encouraging industry to seek out collaborative research efforts with universities. Concern over declining student enrollments has prompted universities to be more aggressive in pursuing industry research for funds to maintain and strengthen their academic departments. Also, growth in real Federal funding for basic research is contributing to the attractiveness of universities as a source of new ideas for industry.

The primary policy recommendation of this chapter is to continue to promote market based collaborations with minimal Federal interference. The policies already in place are factors in the emerging role of academe in the Nation's overall climate for entrepreneurship and innovation, but more can be done. In the interest of accommodating and facilitating university-industry collaboration, Federal policy should:

1. Make permanent the incremental R&D tax credit due to expire in 1985, and include software development in the base;
2. Make deductions of equipment donations to universities for research *and* teaching more generous;
3. Promote and encourage joint R&D ventures, and remove any unnecessary regulatory barriers to university-industry collaboration;
4. Maintain strong Federal Government support for basic research at American universities, and ensure that these funds continue to be allocated on the basis of scientific merit (commercial interests should drive collaborative research but not basic science at universities);
5. Move to a more simplified tax structure but preserve incentives for risktaking and commercial R&D investments;
6. Federal departments and agencies should consider the potential benefits to the economy from collaborative research with universities and industry, as well as efficiency in meeting their mission requirements (one objective of agency collaboration with universities and industry, whenever appropriate, ought to be to speed the process of commercialization of technology developed for government purposes); and
7. Establish a nationwide program to make educational, nonsubsidized loans available to college students, regardless of family financial circumstances, so that no person would be denied an advanced education because of lack of financial resources. The principle and interest would be repayable upon obtaining employment or graduation plus 6 months and automatically collected in equal installments by the Internal Revenue Service until paid in full.

The policy recommendations outlined in this chapter are designed to further technological innovation by encouraging the main actors in that process—universities, government, and industry—to continue to work collaboratively in the development of technologies relevant to the interested parties and to society. The authors believe that university-industry-government collaboration, properly structured and nurtured, provides a viable alternative to federally funded "generic technology center," patterned after agriculture experiment stations, as a means of ensuring continued American technological leadership.

University-industry collaboration reflects private sector interests and not the wishes of government planners. Also university-industry collaboration offers the potential to strengthen the academic mission of the university, on which government *and* industry depend for a technically and professionally competent task force. In general, how Federal Government expenditure, tax, and regulatory problems affect university-industry collaboration will have a significant impact on the rate and direction of technological innovation in the American economy in the years ahead.

IV. GOVERNMENT LABORATORIES AND ECONOMIC DEVELOPMENT

Concern over U.S. technological leadership has led to an interest in the potential of the Federal laboratory system to improve technological innovation. This chapter examines the opportunities and obstacles to technology transfer from Federal Government laboratories to the marketplace. Federal laboratories acquire and develop technology to meet mission requirements—defense, energy efficiency, and environmental protection, but the challenge of public policy—examined in the following sections—is to find ways to speed the flow of technology and expertise to the commercial sector, without sacrificing mission requirements.

Much of the discussion in this chapter is based upon expert testimony before the Joint Economic Committee in its August 7, 1984, hearing on the "Role of Government Laboratories in Regional Economic Development." The expert witnesses at that hearing were The Honorable Clarence Brown, Deputy Secretary, Department of Commerce; Col. Paul J. Theuer, Commander and Director, Construction Engineering Research Laboratory, Champaign, IL; Dr. George Dacey, President, Sandia National Laboratories; Mr. Charles Miller, Lawrence Livermore Laboratory; and Dr. Edward Melecki, University of Florida. Discussions with the Federal Laboratory Consortium for Technology Transfer and the National Aeronautics and Space Administration were also helpful.[1]

Nature of the Issue

The current interest in improving economic conditions at national, regional, State, and local levels has focused attention on increased utilization of the resources of the Federal Government. For the past 10 to 15 years, the Federal laboratory system has served as a technical resource to assist State and local governments in addressing technology-oriented problems they have encountered in the provision of services to the public. For example, to aid in energy conservation, Federal labs have provided heat sensing expertise and equipment for flyovers of public buildings to identify costly heat loss. A computer system developed by the Navy was adapted and applied to assist the New York City police department in monitoring the use of gasoline in squad cars. And, in a cooperative effort to meet a public need, the National Bureau of Standards and the Army Edgewood Arsenal worked with Du Pont and local police departments to develop a bullet proof vest which has saved many lives.

[1] "Government Laboratories and Economic Development," from Part 1 "Climate for Entrepreneurship and Innovation in the United States," hearings before the Joint Economic Committee, U.S. Congress, Aug. 7, 1984.

In the past several years, as more attention has focused on increasing innovation in the private sector, the Federal laboratory system has also been viewed as a resource for technology and technical expertise which can be utilized by both large and small companies. As was indicated in the testimony,[2] various technologies developed in the Federal labs have been transferred to firms where they can be further developed, used and/or commercialized. The Department of Energy's Pacific Northwest Laboratory (run by Battelle) developed ionic additives for paints, a technology which was subsequently transferred to a small local company which it was commercialized. This additive puts a "finger print" on tools used in the oil industry and can be used to detect and identify equipment which has been stolen. In another example, the Army Corps of Engineers developed a computer software system called "Blast" which allows for the assessment of building energy efficiency early in the design process. This system is being utilized by companies such as McDonnell Douglas, Control Data Corp., and Boeing Computer Services, as well as by other firms throughout the world.

As State and local governments look toward innovation-related activities to encourage economic development in their regions, there has been increasing interest in networking the resources of the States, the private sector, and Federal laboratories. In an attempt to create an entrepreneurial environment within the State, the University of Tennessee and Martin Marietta Energy Systems, which runs the Department of Energy's Oak Ridge National Laboratory, have jointly created a Measurement and Control Engineering R&D Center. This center has commitments of $50,000 per year from nine companies including Gulf, Dow Chemical, Olin, Ford, International Paper, Texas Instruments, Koppers, Alcoa, and Robertshaw Control. And in New Mexico, a community project, with funding from the private sector, and with technical expertise provided by Los Alamos National Laboratory, has lead to the creation of an incubator center which will open with 80 percent occupancy in early January. Many of the companies which will locate there are spinoffs from the Federal laboratory and this increased business activity should benefit the local economy.

Public Law 96-480, the Stevenson-Wydler Technology Innovation Act, which mandated technology transfer from the Federal laboratories to the private sector, as well as to State and local governments, was passed in recognition of the positive role Federal laboratories can have in economic development. In this manner, public funds spent in the Federal lab system can have an impact beyond the original intent of the initial investment.

Cooperation in creating an entrepreneurial environment can benefit all the participants. As Congressman Daniel E. Lungren, who chaired the Joint Economic Committee hearings on this issue, stated in his opening remarks:

> The central question concerning America today is how to encourage technological innovation so our economy can compete. . . . The use of the resources and expertise of the

[2] U.S. Congress. Joint Economic Committee. Hearings on "Climate for Entrepreneurship and Innovation in the United States," part 1, 2d sess, 98th Congress.

Federal laboratory system is one way to foster this innovation. The improved flow of technology from government research can be an important component of . . . national innovation policy.[3]

Technology Transfer Defined

The Federal laboratory system has extensive science and technology resources developed as a consequence of meeting the mission requirements of parent agencies. It is thus a potential source of technology and technical expertise which can be utilized in the business community. A portion of the body of knowledge and the store of technologies created in pursuit of the agency's mission may have commercial application beyond the original useage. However the Federal Government does not have the authority and/or ability to further develop, adapt, and commercialize the results of this R&D endeavor. Thus, there is interest in transferring technology to the private sector which has the resources to undertake such activities.

Technology transfer is the process by which technology developed in one organization, in one area, or for one purpose is applied and utilized in another organization, in another area, or for another purpose. Some of the technologies resulting from the Federal Government's sizable investment in research and development may be amenable to transfer to the private sector where they can be further developed to meet market demands and create new and different products and processes. Through the transfer of technology, new solutions to the increasing number of technologically oriented problems can be made in both the public and private sectors.

The value of technology transfer becomes evident when it results in the commercialization of a product or process. Commercialization is a critical step in the innovation process in that it is the activity by which an idea or invention becomes a marketable good or service. It is vital to the promotion of economic growth since the economic benefits of innovation accrue when a product or process is brought to the marketplace where it can be sold or utilized to increase productivity. While the Federal Government directly funds basic research and that applied research necessary to meet the mission requirements of the Federal departments and agencies, commercialization is the responsibility of the private sector.

The Federal Interest

The Federal interest in technology transfer stems from several different concerns, one of which results from the need to buy products and processes, goods and services to meet the operating requirements of the Government. As noted by Colonel Theuer in his testimony, "within the military system, technology transfer means taking that extra step in the R&D process to assure that the R&D product gets into the hands of the military users." Unless industry manufactures the item . . . the Army and Defense Department cannot buy it." The needs of the Federal Government have successfully spawned entire new industries as evidenced by the aviation

[3] Ibid., p. 1.

computer industries, as well as helped older established indus-
; by requiring an ongoing supply of equipment related to na-
al interests or security.

ıe Federal Government's involvement in technology transfer
arises from the recognition that the economic well-being of the
ion is affected by the commercialization activities of the busi-
community. It is often said that the United States has the best
c research enterprise in the world (as evidenced by the number
lobel prizes awarded to U.S. scientists), but other countries—
t notably Japan—often appear more adept at taking this re-
ch and making marketable products. Many times Americans
up purchasing foreign made goods developed out of research
ormed in the United States. As Dr. Dacey testified, in some
s ". . . the foreign competitors are more anxious or at least as
ous to have our [laboratory] technology transferred to them as
own industry is."

novations resulting from the transfer of technology can pro-
economic growth through increased productivity. The work of
ard Denison has demonstrated that from 1948 to 1973, "ad-
es in knowledge (including technical amd managerial knowl-
) are the biggest and most basic reason for the persistent long-
ı growth of output per unit input." [4] Richard Nelson has as-
d that industrial innovation has played a central role behind
run rises in productivity and living standards and has impact-
pon the composition of employment, the structure of industry,
the pattern of imports and exports.[5] Similarly, John Kendrick
ıated that approximately two-thirds of U.S. industrial growth
ıured in real gross product per labor from 1960–73 was attrib-
le to technological advances including changes in labor quality
lting from increased education and experience.[6]

e manufacture of goods, based on the transfer of technology
the Federal Government to the private sector, also helps to
r regional economic development. Colonel Theuer testified that
ı a technology is transferred to the private sector for commer-
ıation ". . . there are secondary effects such as job creation
the development of domestic markets which promote regional
ɔmic development." He explained that a patent licensed by the
s of Engineers for a ceranode will generate a 5 percent royalty
he U.S. Government, increase the work force of the company
; the licensing from 30 to 142 employees, and increase the
s sales by an estimated $8.5 million. "Thus," Theuer stated,
ınology transfer not only results in reduced manufacturing
ɔperating costs by users of these licensed devices, but also gen-
s jobs in the private sector and royalties for the U.S. treasury.
puty Secretary Brown of the Department of Commerce noted
"the best way to get more new technological products for
nal economic development, national growth, and international
ıetitiveness . . . out of the dollars spent on the Federal labs is
ıen their doors to collaboration with the private sector." The

vard Denison, "Accounting for Slower Economic Growth," The Brookings Institution,
p. 79-80.
k presented at CRS seminar. Washington, D.C., June 18, 1980.
ın Kendrick, "Sources of Growth in Real Product and Production in Eight Countries,
978," N.Y. Stock Exchange, 1981.

States have recognized the regional economic benefits to be deri from science and technology and are creating high-technology search and industrial parks to enhance the development of new terprises in these areas. The Federal system has a role, as Bro sees it, in that "for new businesses and jobs to be created muc the technological base will have to come from the Federal labs." an example, Miller cites a program at the NASA Industrial Ap cations Center in Pennsylvania which is sponsored by the local nomic development commission. Workshops are being held w Federal laboratory and industry representatives to link resour on a one-to-one basis with the assumption that new technolo will be developed which will contribute to the economic vitality the area.

While the other witnesses are enthusiastic as to the benefits utilizing the Federal laboratory system, Maleki's studies point what he sees as limitations on the impact Federal laboratories have on regional economic development. Noting that at the curr time most Federal R&D is defense related, he asserts that much the technology developed is not transferrable. According to his t timony, Federal laboratories have generally failed to attract spin off industry. Regional economic development occurs wh there is an "agglomeration" of different R&D-related enterpri including industry, universities, venture capital, and Federal la which contribute to the existing research and development infr structure. Thus, Maleki maintains that Federal R&D only has "notable" effect on regional economic development in large urb areas because Federal R&D funds are spent at firms in a relative small number of locations which can attract competent personn While small, isolated Federal laboratories may generate a sm amount of innovation, most innovation leading to economic grow will occur in "existing clusters of entrepreneurial activity."

The Transfer Process

The transfer of technology can be a long and laborious process. begins with an attempt to identify what knowledge or technology appropriate for transfer—what has potential for commercializ tion—and ends when a good or service is made available in th marketplace. The gap between the work performed internal to th laboratory and the industry which can produce a finished produc or process from laboratory technology is a difficult one to bridge. I cannot be the sole responsibility of the Federal Government. Whil the labs serve as a resource, what is necessary, in view of the testi mony presented, is a cooperative effort between the States, th Federal Government, the private sector, and often universities.

Networking is imperative. The problem, as Deputy Secretary Brown sees it, is that a successful transfer requires links to b made between parties which are unaccustomed to working togeth er. The means to foster these links must be strengthened. While the National Technical Information Service of the Department o Commerce was created to provide information concerning expertise and technologies available within the Federal laboratory system, Brown states that more has to be done in this area because ". . . one of the difficult things that the Federal Government has to do

ıd doesn't always do well, is to relay information from the Gov-
ınment to the private sector." The Government should develop
ıproved mechanisms to allow for the identification of technology
ıd expertise within the Federal laboratories and find ways of
aking this information known to the business community. Con-
ersely, and simultaneously, the private sector has responsibility to
sist in assessing and identifying the commercial viability of feder-
ly funded R&D and should be more receptive to the transfer ef-
rts of the Government.

If regional economic development is a goal, States are critical
ayers in the transfer of technology from the Federal laboratories.
ates act to attract business and, Dacey noted, the labs are a
urce of technology to support State-industry initiatives. States
ın augment the transfer process by acting to bridge the gap be-
veen laboratories and the private sector and to help industry
entify Federal R&D resources. As Colonel Theuer testified, lab-
atories ". . . need to work with the States, who have begun to
velop organizations, often around a university base, to find avail-
ıle technologies in government labs that are transportable to
eir respective States in support of local and regional develop-
ent."

In the process of networking, it is important to consider that
ansfer of technology has the best chance for success when it is
ıdertaken on a case-by-case basis. "Champions" in both the labo-
tory and in industry are necessary to guide the process through
ım the lab to final commercialization in the private sector. Dacey
ints out that technology transfer succeeds when ". . . both par-
s' mutual self-interest are being met." This provides the process
th the committed personnel necessary for achieving a successful
ansfer. When these mutual needs are met it becomes, as Dacey
scribes, a "win-win" situation. The laboratories transfer technol-
y and thereby are able to insure that parts, equipment, and sys-
ns are available for purchase. Private companies have goods to
l to the Government and can develop other products and proc-
es for additional markets. Thus, it is to the benefit of all con-
ned that the technolgy transfer process is facilitated by all par-
ipants.

Current Federal Activities

)ver the years several Federal efforts have been undertaken to
dress the technology transfer issue. The Federal Laboratory Con-
tium for Technology Transfer (FLC) was created in 1974 (from a
partment of Defense program) to assist in transferring technolo-
from the Federal Government to State and local government
d the private sector. The primary purpose of the consortium—a
untary organization of almost 300 Federal labs—is to coordinate
d facilitate the transfer of technology and to promote the effec-
e utilization of the technical knowledge developed within Feder-
departments and agencies. In order to accomplish the goal of in-
ased utilization of Federal R&D, the Consortium establishes
ınnels of communication and interaction between Federal agen-
s and potential users at other Federal departments, at the State
d local level, at nonprofit broker organizations, and in private in-

dustry. These networks create the means through which user quirements can be identified, delineated, and addressed. The C sortium also provides the means by which innovations can be ma available to the private sector for further development and mark ing to the public.

In commercialization of federally funded technology, the Cons tium advertises innovations available to the private sector for ad tional development. In some instances, the Consortium simul neously serves as a broker between State and local units, Fede agencies, and private industry to promote cooperation on a proje One successful effort of the networking that witnesses identified essential to the transfer process involved the development of bullet-proof vest for law enforcement officials. In this case, the Fl identified a need of local government and was successful in brin ing together the resources of the Federal Government and the e pertise of private business to secure the design and manufacture a product vital to local needs. This was accomplished by Feder employees working with State and local officials and industry re resentatives on a one-to-one basis.

To expand on the work of the Federal Laboratory Consortiu and to provide added emphasis on the commercialization of Feder technology, Congress passed Public Law 96-480, the Stevenso Wydler Technology Innovation Act of 1980. Prior to this law, tec nology transfer activities were not an explicit part of the mandat of the Federal departments and agencies with the exception of th National Aeronautics and Space Administration. To provide "legit macy" to the transfer function, Congress, with strong bipartisa support, enacted Public Law 96-480 which requires that:

> It is the continuing responsibility of the Federal Government to ensure the full use of the results of the Nation's Federal investment in research and development. To this end the Federal Government shall strive where appropriate to transfer federally owned or originated technology to State and local governments and to the private sector.

Section 11 of the law creates a system within the Federal Gov ernment to identify and disseminate information and expertise on what technologies or techniques are available for transfer. Offices of Research and Technology Applications were created in each Federal laboratory to distinguish technologies and ideas with potential applications in other settings. This information is required to be forwarded to the newly created Center for the Utilization of Federal Technology (CUFT) at the Department of Commerce. CUFT's responsibilities are to serve as a focal point for access to the system, to disseminate information on the availability of federally generated technology, and to provide whatever additional assistance is necessary to transfer the technology. The Center has been placed under the National Technical Information Service (NTIS) at Commerce. NTIS has had the ongoing function of collecting and disseminating (on a cost recovery basis) information on all federally funded research and development projects. However, as noted previously, Deputy Secretary Brown questioned the effectiveness of the National Technical Information Service and Miller cited a new study which showed that the two primary users of NTIS were the

viet Union and Mitsubishi. Thus, the issue remains, what can be ıe to further develop the environment within which American ns, as well as State and local governments, will be willing and e to better utilize the Federal laboratory system.

Improvements to the Transfer Process

The consensus at the Joint Economic Committee hearings was it the Stevenson-Wydler Technology Innovation Act has made a ıtribution to the promotion of technology transfer, but that more ı, and should be done. Deputy Secretary Brown testified that the / has helped encourage technology transfer in that it makes h activities a matter of national policy and therefore is a basis Federal action. However, Stevenson-Wydler has not solved all problems, according to Brown. He argues that the laboratories l do not perceive the legislation as providing them with the au-ırity to enter into transfer agreements with the private sector. erefore, Brown recommended that Congress pass further legisla-n which provides clear authority, at the laboratory level, for the nsfer of technology and which permits patent licensing decisions be made with the labs themselves as opposed to at the agency el. The laboratory mission should include activities to foster nmercialization by the private sector. Each laboratory should ve, what Brown terms, the "broadcast authority possible" to de-op a working relationship with industry.

The other witnesses testified, however, that Stevenson-Wydler s provide the laboratories with the clear authority to pursue the nsfer of technology to the private sector. As Dacey related, the ndate to transfer technology inherent in Public Law 96-480 has ced a formal emphasis on technology transfer. It legitimizes the nsfer activities which were undertaken prior to the law, and en-rages laboratories where there was little or no transfer to make oncerted effort in this area. Yet, while Theuer, Dacey, and ler all agreed that Stevenson-Wydler provides the technology nsfer mandate, they stressed that it does not provide the incen-s to pursue such activities. What is essential is the development ncentives for individuals within the laboratories to work on the nsfer process and which encourages industry personnel to seek l accept the technology for transfer and eventual commercializa-ı.

peaking to the importance of personal commitment to see a nsfer through to completion, the witnesses suggested that an en-ınment be created that would foster the dedication of laboratory sonnel and the development of "champions." Dacey indicated t the most effective incentive to creating this type of atmos-ere within the labs is to augment the feeling of accomplishment ociated with successful transfer rather than to provide mone-y rewards. It is management's responsibility to project the idea t technology transfer provides a positive and essential contribu-ı to the laboratory' mission. Similarly, Miller indicated that ımonetary incentives such as personnel commendations can be y effective. He concurred in the importance of top manage-nt's commitment to technology transfer, but pointed out that re are no incentives, and several consequences, for innovative

behavior on behalf of laboratory administration. He suggested th management must operate in such a way as to underscore the i portance of the mission requirements of the Federal department agency.

Additional suggestions were made concerning the development an environment within the Federal laboratories which would fost the transfer of technology. Brown recommended that conflict of terest rules be changed to permit Federal lab personnel to purs projects of interests on their own time without forfeiting their F eral jobs. It was also suggested that the individual inventor with the laboratory receive royalties once a technology has been succe fully commercialized. Similarily, another idea would be to pern the royalties collected by the Government to go directly back to t laboratory which effected the transfer to be utilized for other ong ing R&D projects.

There are other barriers to the transfer of technology which a not addressed in the Stevenson-Wydler Act, but which are seen significant by practitioners in the field. Among these are proble associated with conflicts of interest and related legal questions. T Federal Government, and consequently the laboratories are prohi ited from competing with the private sector. Thus, as Dacey poir ed out, it was unclear whether joint ventures between Federal la oratories and State or local governments or industry could be co strued as conflicts of interest. To encourage further risktaking the promotion of technology transfer it is necessary to clarify tho questionable areas regarding the legality of activities involved i the transfer process. He noted that it took over a year to determir issues of legal liability on just one transfer effort. These are diff cult problems, but they must be addressed in order to facilitate th transfer process.

Despite the potential offered by the resources of the Federal lal oratory system, the commercialization level of the results of fede ally funded research and development has remained low. Researc indicates that only approximately 5 percent of federally owned pa ents are ever utilized. From the perspective of industry there ar many reasons for this low level of transfer, one of which is the fac that many technologies have no commercial application. Howeve industry unfamiliarity with Federal technologies, the "not-invent ed-here" syndrome, and perhaps most significantly, as discusse below, the ambiguities associated with obtaining title to or exclu sive license to federally owned patents also contribute to the limit ed levels of transfer.

Promotion of invention and commercialization of technology i one major objective of the patent system and in most cases thi goal is furthered by government policy and practice. However, on aspect of government patent policy—that which pertains to inven tions made under Federal funding—has come under criticism as ar impediment to technology transfer. In most cases (with the excep tion of universities, small businesses, and not-for-profit institu tions), title to inventions made with Federal monetary support is vested in the Government. The Government's financial contribu tion to research and development has resulted in the generation of over 28,000 patents. A portion of these patented ideas have poten tial for further development, application, and commercialization.

Yet, as noted above, research has shown that only approximately 5 ercent of government-owned patents are ever introduced into the rivate sector.

Critics of the present system assert that government policies conerning ownership of title and nonexclusive licensing practices ave resulted in this low level of commercialization and use of fedrally owned patents. As Dacey testified, industry needs proprieary rights if it is to undertake commercialization. The argument roposes that, without title to an invention and the 17-year exclusivity it provides, an individual or company will not invest the time nd money necessary for the development of a marketable product.

The Congress has accepted to a limited extent the contention hat vesting title to the contractor will encourage technology trans-r and commercialization. Public Law 96-517, Amendments to the atent and Trademark Laws, provides, in part, for title to be ested in contractors if these are small businesses, universities, or ot-for-profit institutions. Certain rights are reserved for the Govrnment and these organizations are required to commercialize ithin a predetermined and agreed upon timeframe. Yet it contines to be argued that patent exclusivity is important for both large nd small firms. In this spirit, President Reagan issued a memondum in February 1983, which instructed all Federal departents and agencies to treat, as allowable by law, all contractors reardless of size as prescribed in Public Law 96-517 with regard to ie ownership of title.

It has been suggested that to further encourage this transfer fort, patent licensing authority be given to the individual laboraries. As Brown testified, the issuing of licensing at the agency vel tends to increase bureaucratic complications which can be oided by giving patent responsibility to the specific laboratories volved in the transfer process. This concern was addressed in the osing days of the 98th Congress. Title V of Public Law 98-620 akes certain amendments to the Patent and Trademark laws hich should improve the transfer of technology from the Federal boratories to the private sector and increase the chances of sucssful commercialization of the results of federally funded rearch and development. This law permits Federal laboratories to ake decisions at the laboratory level as to the granting of exclue licenses for government-owned patents. This has the potential effecting greater interaction between laboratories and industry the transfer of technology. Patent royalties are also permitted to back to the laboratory or university (in the case of governmentned, contractor operated labs (GOCO)) to be used for additional &D, awards to individual inventors, or education. While there is a p on the amount of the royalty returning directly to the lab in ler not to disrupt the agency's mission requirements and conessionally mandated R&D agenda, the establishment of discrenary funds gives laboratories added incentive to encourage techlogy transfer.

Several other provisions of Public Law 98-620 can be foreseen as eting some of the concerns expressed during the Joint Economic mmittee hearings. Private companies, regardless of size are alved to obtain exclusive licenses for the life of the patent. Prior strictions allowed large firms use of exclusive license for only 5

of the 17 years of the life of the patent. This should encourage i proved technology transfer from the Federal laboratories or t universities (in the case of university operated GOCO's) to large c porations who often have the resources necessary for developme and commercialization activities. In addition, the law perm GOCO's (those operated by universities, nonprofit institutions small businesses) to retain title to inventions made in the labora ry within certain defined limitations. Those laboratories operat by large companies are not included in this provision. Under Pub Law 96-517, the operating units of GOCO's were specifically p hibited from obtaining title.

Summary and Recommendations

The Federal laboratory system has been a subject of increasi interest in public policy discussions on how to preserve U.S. techi logical leadership. Finding ways to improve the flow of technolo and expertise from Federal laboratories to the commercial sector seen in this study as an important component of a comprehensi strategy to improve the Nation's climate for entrepreneurship a innovation.

Many Federal policies are now in place to improve technolo transfer, but apparently much more needs to be done. Some imp tant Federal actions include the Stevenson-Wydler Innovation A of 1980 and changes in U.S. patent policies. The former provides congressional mandate—and authority—for Federal Governme departments and agencies to seek ways to speed the commercializ tion of technology developed under Federal contract or in gover ment laboratories. Important actions to date include the establis ment of the National Technical Information Service and the Cent for the Utilization of Federal Technology within the Department Commerce and the authority to establish Offices of Research ar Technology Applications in major Federal Government laborat ries. Many laboratories have responded to their new authority ar responsibility, but the consensus of expert opinion before the Joi Economic Committee is that lines of authority and incentive stru tures are inadequate. Much more can and needs to be done t maximize the commercial benefits from Federal laboratory r search.

The primary deficiency of the current system of technolog transfer is the lack of explicit incentives at the laboratory level t network with private businesses, universities, and State and loc governments. Also, although the authority is there, many toug legal and potential conflicts of interest problems arise. What ar the rights and responsibilities of government employees in workin with industry on technology transfer? What are the antitrust in plications of government laboratories working directly with indu try? How should patent and royalty fees from successful technolog transfer programs be divided among the laboratories, employee Federal agencies and departments, and the U.S. Treasury?

Probably the most significant new actions to improve the tech nology transfer process would be those that focus on establishin general guidelines for laboratory-industry collaboration. In add tion, identifying responsibility for technology transfer at th

agency level, and within laboratories, would be a significant improvement over the current arrangement. In general, providing maximum discretionary authority for technology transfer at the laboratory level—consistent with general Federal department and agency guidelines and oversight—would be desirable. The advantage of decentralized authority is that it allows each laboratory flexibility in designing and implementing technology transfer programs consistent with the mode of operation of the laboratory.

Changes in Federal patent policies to give title to inventions from federally funded research to universities, small businesses, and not-for-profit organizations provides a strong incentive to bridge the gap between laboratories—and universities—and the private sector. Establishing patent offices within Federal Government laboratories to enable them to lease or sell technology to the private sector needs to be the responsibility of each Federal laboratory. Sharing the fees from laboratory-industry collaboration could provide the much needed financial incentive for laboratory officials to take technology transfer seriously, and to reward those responsible for successful technology transfer. Currently, legal authority is already provided for these functions, but lacking guidelines for acceptable laboratory-industry collaborations, many laboratory officials and research scientists are reticent to experiment with new technology transfer approaches.

The following are this study's recommendations for strengthening the authority for technology transfer mandated in Public Law 96-480, the Stevenson-Wydler Innovation Act of 1980; clarifying legal and conflict of interest issues; and promoting networking between government laboratories, universities, industry, and State and local governments in regards to technology transfer:

1. Strengthen Authority for Technology Transfer

Provide a full-time professional staff position in the Office of Research and Technology Applications within each major Federal laboratory, with responsibility for technology transfer programs, networking, and providing patent and legal advice to management and laboratory employees.

Include technology transfer in management's job evaluations, job descriptions, and employee promotion policies.

Establish awards within the laboratory for the successful completion of technology transfer, including compensation for the laboratory and those individuals responsible for the successful programs.

Establish guidelines and conflict of interest regulations and rules regarding laboratory-industry collaboration, including rules and guidelines for laboratory employees working in industry.

Permit each laboratory to develop individual technology transfer programs which complement the mode of operation of the lab. Each Federal department and agency should be required to establish explicit authority within laboratories under their jurisdiction for technology transfer.)

2. Legal Clarification

Clarify conflict of interest rules as they pertain to joint Federal laboratory private industry activities.

Clarify the legal rights and responsibilities of Federal laboratories in joint ventures.

Clarify conflict of interest regulations regarding Federal laboratory personnel (permit businesses on the side, consulting with private firms, allow equity interest in other companies).

3. Encourage Networking

Encourage Federal laboratories to participate in new and/or ongoing State/university/private sector programs.

Encourage States to create mechanisms to identify technology in Federal laboratories which either can be utilized in the States' provision of services or which can meet economic development needs

Identify the Federal Laboratory Consortium as the primary coordinating organization for the promotion of technology transfer Provide a statutory basis for the Consortium.

Improve the operation of the National Technical Information Service and the Center for the Utilization of Federal Technology as another networking mechanism.

To implement the study's recommendations, a Commission on Technology Transfer should be convened, by Congress, to establish the necessary operating guidelines and procedures. Laboratory directors and scientists, Federal department officials, business representatives, the Federal Laboratory Consortium, State and local officials, and other appropriate groups ought to be represented on the bipartisian Commission, which would be given the responsibility of recommending explicit guidelines and conflict of interest rules to encourage networking, technology transfer, and the dissemination of technical information.

V. STATE INNOVATION STRATEGIES

A discussion of the Nation's entrepreneurial climate would not be complete without considering the innovation strategies of State and local governments in response to the realities of the 1980's. The new strategies emphasize expansion of the high-technology industries—but not to the exclusion of other industries—and the transfer of technology throughout all the segments of society. In general, the "State high-tech involvement" is the spatial analog of the transformation of American industry and society to a much greater reliance on the high-tech and service industries.

The pursuit of high-tech activities by the States is consistent with the view that industrial innovation is the "wellspring" of economic progress in an information economy. Industries like computers, semiconductors, aerospace, chemicals, biotechnology, and telecommunications have a considerable job generating potential in their own right but the spread of advanced technologies to other industries, such as the services and basic manufacturing, has the potential to create many more jobs. It is probably safe to say that the lion's share of productivity growth and job expansion in the future will depend, directly or indirectly, on the computer and other advanced technologies.

The underlying theme of this chapter is that it is in the national interest for the States and regions to pursue development strategies consistent with technological change in the American economy and its realignment in international markets. Toward this end, the States are reorienting their development efforts to be consistent with the locational and expansion needs of high-tech companies. The engrained practice of chasing the "smokestack industries" with generous financial incentives has been giving way to a strategy that places much greater emphasis on problems encountered in product development, technology transfer, capital formation, and industrial innovation.

A common feature of the high-tech strategies, examined in this chapter, is their reliance on market incentives to encourage the necessary entrepreneurship and risktaking to exploit commerical opportunities resulting from basic and applied research. The States are taking significant actions to stimulate entrepreneurship and innovation by removing technical, labor market, financial, and other barriers to business expansion. To do this, many States are investing in basic research, improving university high-tech linkages, networking with government laboratories, improving venture capital financing for the State's fledgling entrepreneurial companies, and initiating regulatory reform. Above all, and most encouraging, the States appear to be making a long-term commitment; they are attempting to integrate and coordinate a wide range of State tax, expenditure, and regulatory policies to provide a better overall entrepreneurial climate.

The chapter proceeds by examining the leading issues involve in creating a climate for innovation and high-tech growth at th regional level. Then, the experiences of Utah, North Carolina, an Pennsylvania, in their attempts to create a better climate for en trepreneurship and innovation, are examined. The discussion i concluded with an overall assessment of the State and local high tech movement and its implications for national public policy.

Creating a Climate for Innovation and High Technology

In discussing what a successful State and local government deve opment strategy ought to look like, Roger J. Vaughan, a leadin expert in regional economic development, had this to say:

> An economic development strategy must focus on the overall economic climate, and not waste resources on special incentives for new favored firms. It must encompass a broad range of policies including training programs, infrastructure development and capital mobility as well as a balanced tax structure.[1]

Which attributes of local communities are most important t their ability to attract, maintain, and nurture innovative busines es? George A. Reigeluth and Harold Wolman, in a 1979 Urban In stitute study, present the following definition of competitive ad vantage:

> A community is said to have a competitive advantage in a particular economic activity, when the products of that activity can be sold at prices which simultaneously underbid the prices of similar commodities produced at other locations, and which generates larger rates of return for firms in that community than for similar firms in other locations.[2]

As a practical matter, comparative advantage depends upon the lo cational characteristics of a community (e.g., geographic location labor force, natural resources, transportation, business climate quality of life, etc.) and its access to markets.

An examination of the locational determinants of high-tech companies provides a starting point for evaluating the policy options available to States trying to encourage industrial innovation and high-tech expansion.

Until the Joint Economic Committee Survey of High-Technology Companies in the United States, knowledge of high-tech locational decisions was largely antedotal.[3] In all, 691 executives of high-tech companies responded to the survey. They represent companies in a wide variety of industries, including the telecommunication, medical equipment, computer research, semiconductor, aerospace, chem-

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[1] Roger J. Vaughan, "The State and Federal Role in High Technology Development," a paper presented at a symposium on Technology and Regional Development: The Policy Issues, Syracuse University, April 1984.

[2] George A. Reigeluth and Harold Wolman, "The Determinants and Implications of Communities Changing Comparative Advantage: A Review of Literature," Washington, DC: The Urban Institute, 1979.

[3] Robert Premus, "Location of High Technology Firms and Regional Economic Development," staff study prepared for the Subcommittee on Monetary and Fiscal Policy of the Joint Economic Committee, Congress of the United States, May 1982.

al and defense industries. California and Massachusetts were sted as home for 322 and 155 of the responding companies, respecvely. The remainder were scattered throughout the other States nd regions.

The JEC Survey defined high-technology companies as companies iat rely on technological innovation to remain competitive. Comanies that (1) employ a high percentage of engineers, scientists, id technicians in their work force, (2) are heavily dependent upon &D inputs, and (3) are engaged in developing and marketing new oducts and services that embody the latest technology were inuded in the survey. In general, these unique characteristics of gh-tech companies reflect their role as suppliers of new products id services made possible by advances in basic science. Since they erate at the early stage of the product development cycle, marts are not clearly defined and there are potential numerous technical, labor market, and finanical barriers to product development id firm growth. Consequently, market and technical risks are gh, making access to skilled labor, research, and venture capital iportant factors in the overall climate for high-tech expansion.

Locational Determinants

The unique characteristics of high-technology companies are reected in their locational requirements. (See Table V.1.) Not surisingly, the availability of skilled labor (scientists, engineers, and chnicians) ranked first on their list of priorities when choosing a cation among the regions of the country. Labor costs ranked cond followed by State and local taxes. Academic institutions and e cost of living were ranked fourth and fifth as regional location-attributes. Following these regional, or first stage, locational deminants were community level factors such as regulatory praces, cost and availability of land, room for expansion, good local iools and local transportation. (See Table V.2.) These second ige factors primarily influence the choice of location sites within egion.

BLE V.1.—FACTORS THAT INFLUENCE THE REGIONAL LOCATION CHOICES OF HIGH-TECHNOLOGY COMPANIES

Regional attribute	Percent significant or very significant [1]
Labor skills/availability	89.3
Labor costs	72.2
Tax climate within the region	67.2
Academic institutions	58.7
Cost of living	58.5
Transportation	58.4
Access to markets	58.1
Regional regulatory practices	49.0
Energy costs/availability	41.4
Cultural amenities	36.8
Climate	35.8
Access to raw materials	27.6

espondents were asked to rate each attribute as "very significant, significant, somewhat significant, or no significance" with respect to their n choices. The percent of "very significant and significant" responses were added together to obtain an index of overall importance.

rce: Joint Economic Committee Survey of High-Technology Companies in the United States (Premus, 1982, p. 23).

TABLE V.2.—FACTORS THAT INFLUENCE THE LOCATION CHOICES OF HIGH-TECHNOLOGY COMPANIES WITHIN REGIONS

Rank	Community attribute	Percent significant or very significant
1	Availability of workers	96.1
	Skilled	88.1
	Unskilled	52.4
	Technical	96.1
	Professional	87.3
2	State and/or local government tax structure	85.5
3	Community attitudes toward business	81.9
4	Cost of property and construction	78.8
5	Good transportation for people	76.1
6	Ample area for expansion	75.4
7	Proximity to good schools	70.8
8	Proximity to recreational and cultural opportunities	61.1
9	Good transportation facilities for materials and products	56.9
10	Proximity to customers	46.8
11	Availability of energy supplies	45.6
12	Proximity to raw materials and component supplies	35.7
13	Water supply	35.3
14	Adequate waste treatment facilities	26.4

Source: Joint Economic Committee Survey of High-Technology Companies in the United States (Premus, 1982, p. 23).

There are several noteworthy characteristics of high-tech company locational choices. First, high-tech companies show an affinity for location sites that offer ample supplies of scientists, engineers, and technicians, preferably near a major university system. Second, unlike other businesses, high-tech locational choices appear to be quite sensitive to tax differentials among the States and regions. Third, physical proximity to raw materials and markets is of little importance to the "footloose" high-tech companies. Finally, the locational choices of high-tech companies are influenced by a wide range of community factors, such as good schools, business climate, local transportation, and land assembly costs.

It is important to note that many of the high-tech locational factors can be directly influenced by State and local expenditure, tax, and regulatory policies. This is an important finding since it suggests that States and communities have within their power the means to improve their region's environment for entrepreneurship and innovation. However, the fact that most high-tech locational attributes are a shared responsibility of Federal, State, and local governments creates a need for government cooperation and coordination. Getting the necessary intergovernmental cooperation represents a formidable political barrier in many States and regions.

The Role of Universities

The strong dependence of high-tech companies on the skilled segment of the labor force attests to the important role that universities and technical schools play in high-tech development. Universities are major suppliers of skilled labor, but, in addition, they are the primary originators of advances in basic science that ultimately lead to new products and processes. Thus, a major challenge confronting State economic planners is to simultaneously strengthen academic institutions, find ways to stimulate "spinoff" companies

from university research, and increase the rate of technology transfer to existing businesses. The establishment of university-based science parks and innovation centers are examples of linkages that many States are using to strengthen university-business ties. Joint research efforts and expanded industrial affiliate programs are other important mechanisms for improving high-tech linkages. Perhaps experimenting with ways to encourage a recoupling of industry and academe is the single most important public policy innovation that is being pursued under the rubic of the "State high-tech movement."

Creating an Investment Climate

Basic research at universities, strong industry ties, and an abundance of skilled labor are not sufficient conditions to spur innovation and high-tech expansion. If major barriers to entrepreneurship are present (e.g., an onerous tax system or inadequate location sites) many potential high-tech commercial opportunities may remain unexploited. For this reason, a high-tech strategy must include efforts to improve the States' overall investment climate to complement its human capital and basic research policies. This section considers nine potential State actions to improve a region's investment climate and what high-tech executives think about the likely success of these actions.

The views of the high-tech executives on State development actions are taken from the responses the Joint Economic Committee's 1982 Survey of High-Technology Companies in the United States. Table V.3 lists nine of these State actions included on the survey and the percent of the high-tech executives that felt that the action would have a "very significant or significant" impact on business (investment) expansion. An analysis of the survey results for each of the potential State actions follows:

TABLE V.3.—THE IMPACT OF ALTERNATIVE STATE POLICY ACTIONS ON THE EXPANSION OF HIGH-TECHNOLOGY INDUSTRIES

Rank	Alternative state	Very significant (percent)
1	Cut redtape	84.9
2	Reduce taxes	84.5
3	Offer financial incentives	79.8
4	Improve community attitude	55.5
5	Train labor	48.8
6	Reduce lost time during inspections	47.6
7	Improve cultural amenities	38.6
8	Improve recreational facilities	36.1
9	Procure resources from local businesses	28.6

Source: Joint Economic Committee Survey of High-Technology Companies in the United States.

Cut Redtape

The high-tech executives apparently view regulatory redtape as a significant barrier to State and local economic development. Over 80 percent of the high-tech executives in the Joint Economic Com-

mittee Survey listed "cut redtape" as likely to have a "very significant or significant" impact on business expansion.

There are sound theoretical reasons why high-tech companies view the regulatory burden as a serious impediment to expansion. First, high-tech companies operate at the early, or expansion, phase of the product life cycle. It is at this stage of business expansion that the regulatory maze has its greatest opportunity to stymie company expansion. In fact, the "capture theory" of regulation suggests that the established companies view the regulatory process as a means of protecting their established markets against would-be competitors.[4] Being outside of the political process, the young, high-tech companies are much more likely to view regulations as an obstacle to expansion.

Second, high-tech companies generally operate on a short product life cycle because of technological obsolescence. Technological obsolescence is a fact of life for many of the high-tech companies. They must continually innovate, or engage in competitive innovation, to maintain or expand their market shares. Thus, to be profitable in a rapidly changing technological environment, the commercial exploitation of high-tech investments must proceed relatively rapidly. Time delays associated with obtaining zoning changes, design approvals, and other regulatory redtape can lengthen the investment period and add significantly to risks. Lost time can reduce the ability to raise the necessary large sums of venture capital to exploit new commercial opportunities.

Third, unnecessary regulatory requirements can significantly alter the entrepreneurial nature of the free enterprise system.[5] Valuable entrepreneurial resources must be diverted to meeting regulatory requirements. The loss of these entrepreneurial resources is particularly critical to high-tech companies that operate at the early, or expansion, phase of the product development cycle. For these reasons, the regulatory burden can act as a significant barrier to high-tech expansion, explaining the high priority given to regulatory relief by high-tech executives.

Finally, the location of high-technology investments is also affected by regulatory requirements. Over 70 percent of the high-tech executives felt that State and local regulations had at least some impact on locational choices. About 35 percent of the high-tech executives rated State and local regulations as having a very significant or significant impact on locational choices.

States can take several steps to relieve the regulatory burden. One would be to establish a regulatory review board to examine ways to more efficiently manage the regulatory process, to review the impact of regulation on the State's business climate, and to recommend the necessary regulatory changes. Another action might be to institute "one-step permitting" as is used in Washington and Oregon. Another important approach might be to provide regulatory relief to new and expanding businesses, particularly in urban "enterprise zones."

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[4] George J. Stigler, "The Citizen and the State," Chicago: The University of Chicago Press, 1965.

[5] Murray L. Weidenbaum, "The High Cost of Government Regulation," Challenge, December 1979, pp. 32–39.

Cut Taxes

The high-tech business community apparently places tax policy high on its agenda of recommended State actions to encourage business investment. In particular, over 80 percent of the high-tech executives listed "reduce taxes" as likely to have a very significant or significant impact on the expansion of business investments.

There are several reasons why taxes are important to high-tech companies. First, taxes cut into corporate cash flow and make it more difficult to pay the wages and salaries necessary to compete for scientists, engineers, technicians, and other key personnel. In fact, in a recently conducted National Science Foundation survey, high-tech companies listed lack of financial resources to pay competitive salaries as their largest problem.[6] For companies that depend upon scientific inputs to remain competitive, the tax burden can be a serious constraint to expansion. Second, taxes can significantly reduce the flow of available venture capital for high-tech expansion. A recent Government Accounting Office (GAO) study found that the availability of capital is quite sensitive to government tax policies. In particular, the GAO found that high taxes (particularly the capital gains tax) reduced the flow of available venture capital to the risk-oriented high-tech companies.[7]

A State policy of reducing business taxes and raising personal taxes is not likely to bring much relief. Personal taxes can likewise adversely affect the emerging high-tech industries. The skilled segment of the labor market, upon which high-tech companies so keenly depend, is the segment that is most affected by high personal tax rates. However, in a seller's market the State tax burden is likely to show up on the wage demands of scientists, engineers, technicians and other personnel. By reducing corporate cash flow, the high-tech companies would be in a less favorable position to attract the necessary labor skills.

The high rating given to "cut taxes" should not be taken literally as a recommended State action without regard for other factors. The need for support services such as adequate funding for universities, good schools, airport facilities, and good local transportation—and expenditures to satisfy the noneconomic objectives and social responsibilities of State government—must also be considered. It does suggest, however, that unnecessary government spending, administrative inefficiencies and an overly generous commitment to social programs, by leading to higher taxes, can undermine the vitality of a State's entrepreneurial community.

Offer Financial Incentives

Providing financial incentives is by far the most widely used development tool at the State and local level. Most States have the enabling legislation to permit the use of tax incentives such as property tax abatement and investment tax credits. The objective of these tax incentives is to raise the after-tax rate of return on

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[6] William L. Stewart and Norman W. Friedman, "Problems of High Technology Firms," National Science Foundation, Special Report (NSF 81-305), December 1981.

[7] U.S. General Accounting Office, "Government-Industry Cooperation Can Enhance the Venture Capital Process," Report to Senator Lloyd Bentsen, Joint Economic Committee, U.S. Congress, Washington, D.C., Aug. 12, 1982.

new investments. Also, most of these same States have capital subsidy schemes such as loan guarantees, industrial development bonds, and direct loan programs. The objective of the capital subsidy schemes is to lower the cost of capital to businesses expanding within the State.

The effectiveness of these policy instruments to stimulate business expansion depends upon the net interest elasticity of the State's investment demand schedule. The fact that 80 percent of the high-tech companies felt that financial incentive schemes will have a "very significant or significant" impact on business expansion, suggests that they view the investment schedule as interest elastic, or responsive to the net interest differentials among the States created by the financial incentive programs.

Apparently, financial incentives will have more of an influence over the startup and expansion decisions than they do over the location decisions of high-tech businesses. In another question, only 24 percent of the high-tech companies listed financial investments as affecting their company's location decision. The majority of the high-tech executives rated the impact on financial incentives on their company's location decisions as insignificant. Thus, it would appear that the high-tech executives view traditional financial incentives as influencing startups, expansions, and investment in new technologies. Plant relocations are largely unaffected by subsidies, implicit or explicit.

Improve Community Attitudes

The high-tech executives listed "improve community attitudes" as the fourth most important action that States could undertake to encourage high-tech expansion. The ability of a region to assimilate new ideas and adjust to change can be a significant factor in the expansion of innovative companies. Resistance to technical change can come from top corporate management, lower echelon managers and the public at large. Unions, too, all too frequently view technical change as the enemy of labor; yet, ironically, technical change is the major source of growth in real per capita income, jobs, and leisure.[8]

Train Labor

An apparently effective development tool pioneered in South Carolina and used throughout the Sunbelt region is the "preemployment training program" concept.[9] The typical preemployment training program offers specific training to prospective employees of new or expanding companies within the State. There is little or no cost to the business or the trainee. The State employment agency generally is utilized to screen prospective employees who must agree to enroll in the preemployment training program as a condition for employment. The corporation endorses an agreement of intent to hire those individuals that successfully complete the

[8] Clinton C. Bourdon, "Labor, Productivity, and Technological Innovation: From Automation Scare to Productivity Decline," Christopher T. Hill and James M. Utterback, eds., Technological Innovation for a Dynamic Economy, Pergamon Press, 1979, pp. 222-254.

[9] Michael McManus, "Work Training Need Not Be Costly," The Northern Perspective, 1982.

training program. Thus, the company benefits by having a trained labor force with the skills required on the day the new facility is to open.

The low rating given to training labor suggests that high-tech companies do not look to these programs as a source of the labor skills required in their operation. The generally short nature of preemployment training programs, typically 13 weeks or less, is unsuited to the labor market requirements of the high-technology companies. However, the high rating given to skilled labor (technical workers, engineers, and scientists) in locational choices in Table V.2 suggests that technical schools, and community colleges, as well as universities, have an important role to play in providing a high-tech environment for innovation and technology transfer to local and regional businesses.

Reduce Lost Time During Inspections

State inspection procedures ranked relatively low in terms of significant State action, but, nonetheless, there is some room for improvement. Over 38 percent of the high-tech executives viewed improved inspection procedures as likely to have a very significant impact on business expansion. Government regulations that affect the expansion of businesses is another matter. As discussed previously "cut redtape" was listed as one of the most important actions States could take to encourage capital formation and innovation.

Improve Cultural/Recreational Amenities

State policies to improve cultural and recreational amenities and facilities to attract industry were rated by the high-tech companies near the bottom of the list of alternative State action. This finding contradicts the common belief that high-tech employees, because of their generally higher education levels, will place a premium on those locational sites that offer attractive cultural and recreational opportunities.

Procedure Resources From Local Businesses

Finally, a "buy local" policy to stimulate high-tech development received very little support from the high-tech executives. The theory behind "buy local" campaigns is straightforward. To the extent that State purchases are switched to in-State suppliers, local demand will increase, allowing more jobs to be created.

While on the surface it may appear that this approach has some merit, it, nevertheless, suffers from several fatal flaws. First, State governments would be subsidizing inefficient suppliers, but even if this can be overlooked, few jobs are likely to be created because firms in the high-tech industries sell in national and international markets. In this case, product demand would be shifted from one State to another with little or no impact on labor demand. Thus, it is very unlikely that this policy would have any significant impact on the interstate distribution of high-tech companies. Even if it did, however, other offsetting factors will occur. In an open, interdependent system, high-tech businesses in other States will demand similar actions against out-of-State suppliers. The net effect will be

higher costs for all State and local governments from inefficient procurement policies, and no perceptible impact on the spatial distribution of high technology jobs.

The Experience of Utah, North Carolina, and Pennsylvania

The normative question of what States should do to improve their climates for innovation and technological change was discussed in the previous section. This section examines the strategies of several States to determine what States are actually doing to "target the process of innovation." In particular, the strategies being implemented in the States of Utah, North Carolina, and Pennsylvania to induce innovation and high-tech growth are examined. The discussion is based upon testimony presented before the Joint Economic Committee on August 9, 1984, by Gov. Scott M. Matheson of Utah, Gov. Dick Thornburgh of Pennsylvania, and Donald S. Beilman, President of the Microelectronics Center of North Carolina.[10] The testimony of Peter Brennan, professional consultant, presented at that hearing, is also used as a basis for this evaluation.

The policy strategies of States participating in the "high-tech movement" generally place major focus on overcoming shortages of skilled labor, technological barriers to product development and improved process technologies, and financial barriers to business expansion. The strategies of Utah, North Carolina, and Pennsylvania were chosen for indepth analysis because their approaches are representative of what other States and regions are doing to encourage technological innovation.

Utah

Utah's high-tech approach places major emphasis on policies that augment the supply of scientific, engineering, and technical workers. This is being accomplished through expanded university degree programs, the creation of centers of excellence, and by improving science and mathematical training in elementary and secondary schools.

Utah's population growth rate is the highest in the Nation; hence, the need to accelerate job expansion is of paramount importance to this State. Utah's four universities and two technical institutions, all located along the Wasatch Front, the 100-mile corridor stretching from Logan on the north to Provo on the south, have been instrumental in meeting the skilled manpower needs of high-tech firms in Utah.

The U.S. Department of Labor-funded pilot program, the Wasatch Front Enterprise Center, assists new business owners in learning about the labor and management skills they need in their new business venture. This center bridges the gap between the technical and management skills of the entrepreneur. The Wasatch Front Private Industry Council, which is associated with the center, is a cooperative effort between government and private business to train and place qualified individuals in the dynamic

[10] "State Strategies To Improve the Climate for Innovation and Economic Growth." Testimony presented before the Joint Economic Committee, U.S. Congress, Aug. 9, 1984.

labor market. The Federal Job Training Partnership Act programs are placed under the jurisdiction of the Department of Community and Economic Development to ensure that the resources are well coordinated to provide the skills necessary for State economic development.

Utah has a science adviser and an advisory council on science and technology to advise the Governor and the legislature. The purpose is to encourage technological innovation in both private and public sectors. The State's university system fosters a mutually beneficial partnership between the university and high-tech industry. A case in point is the College of Engineering at the University of Utah, which has become a center for high-technology research. Government and private funding for this effort totals $8 million annually. The College of Engineering is now ranked in the top 20 nationally in research support.

Besides providing facilities to develop technology, both Utah State University and the University of Utah have established innovative channels to transfer new products to private use. The University of Utah's Patent and Product development office actively recruits firms to license university technology. An interesting aspect of this program is that the university will accept equity interest in a company as payment for a license. This has enabled 20 small startup companies to obtain licenses since 1981.

The University of Utah has also developed a research park to facilitate the interaction of university knowledge with industry. The park represents an investment of $85 million. One of the residents of the park, the Utah Innovation Center, was established in 1977 with funds from the National Science Foundation. In return for an equity position, or a share of interest in a firm's technology, the Center provides venture capital, management assistance, technical library office space, and secretarial and legal services. Since 1982 when the Federal funding ended, the Center has become a private firm in conformity with the National Science Foundation's hope that it would evolve into a self-sustaining entity.

The State has developed a number of financial innovations to induce economic growth and high-tech development. A case in point would be the research and development tax credit enacted by the Utah Legislature in 1974. A blanket exemption of the sales tax on new manufacturing equipment is currently being considered. Utah is also developing a capital budget system which is indicative of a strong commitment to improving their public infrastructure.

Utah actively participates in the Federal Small Business Revitalization Program which makes SBA 503 loans and Urban Development Action grant funds available to the States. Of the 34 States involved, Utah ranks first, on a per capita basis, in the amount of money placed with small businesses.

Another institution which encourages the establishment and growth of new high-technology businesses is the Utah Technology Finance Corporation. The newly created corporation has received money from both public and private sources, including Federal and State funds, and it provides seed money in several areas including research contracts, program grants, equity investment, convertible loans, and venture financing. The corporation also has a State Small Business Innovation Research Program (SBIR) similar to the

Federal SBIR and will provide research and development finance to meritorious applications only partially funded by Federal programs.

North Carolina

This State has a long, successful tradition of pursuing high-tech growth. The effort began formally in 1959 with the opening of the Research Triangle Park. Its 5,500 acres are dedicated to a mixture of research, service, and high-tech activities. The Research Triangle Foundation, which is responsible for the park development, stresses the importance of a close relationship between the parks occupants and Duke University (8 miles away), North Carolina State University (14 miles away in Raleigh), and the University of North Carolina (12 miles away in Chapel Hill).

IBM, Northern Telecom, Burroughs, Monsanto, and Data General are among the major corporations now located in the park, giving the Research Triangle Park world class status.

Recent efforts have been taken by North Carolina to expand and improve technology-related research, education, and training programs throughout the State. These efforts can be broadly grouped under the following headings:

1. Modern technical education—$80 million was earmarked for the State's community college system. This system includes 58 campuses across the State. Ninety percent of the population is within commuting distance of one of these community colleges and 600,000 citizens participate each year in their educational programs. Programs are continually updated to include the skills necessary to support new technology industry.

2. Higher education and training—$27.4 million was earmarked for the university engineering and computer science buildings. The major goal is to improve the quality and quantity of output of graduate programs in science and engineering at North Carolina universities.

3. Applied research—$32 million has been allocated for the North Carolina Biotechnolgoy Center and the Microelectronics Center of North Carolina.

The Microelectronics Center of North Carolina has established itself as a major national resource for modern electronics by combining the resources of five universities (Duke University, North Carolina A&T University, North Carolina State University, University of North Carolina at Chapel Hill and University of North Carolina at Charlotte) and the Research Triangle Institute.

The State encourages the startup of new firms through three basic mechanisms: a State initiative, increased Federal support, and private investment.

The State initiative includes the establishment of a Technical Development Authority (TDA) which helps local communities establish incubator facilities to nurture new firms. Last year (TDA's first) TDA invested $225,000 of State money in five new ventures.

The State helps North Carolina firms participate in the Small Business Innovation Research (SBIR) Program. In the first round of the program, North Carolina firms won 18 awards amounting to $778,265. The award ratio of 1 in 6, is one of the best in the Nation.

Public and private investment in research and development in North Carolina is over $600 million per year. These investments in R&D are expected to result in increased spinoff companies which would in turn stimulate additional use of technology and further economic growth.

Pennsylvania

This State has a unique program called the "Ben Franklin Partnership" which represents a consortium of business, labor, research universities, and other higher education institutions, and economic development groups. This young program is designed to move advanced-technology initiatives out of the laboratory and into the shop floor to create new jobs and business opportunities. This program has centers at Lehigh University, Pennsylvania State University, Philadelphia's University City Science Center, and jointly at the University of Pittsburgh and Carnegie-Mellon University.

During this fiscal year, Pennsylvania hopes to exceed $100 million in public and private financing committed to the largest annual State technological innovation program in the Nation. In addition, about $12 million in venture capital has been attracted to Ben Franklin supported programs. Pennsylvania now has in operation the largest number of small business incubators of any State in the Nation. One of the main reasons for the success of this program is the catalytic private sector acting as its driving force. Private sector representatives serve on the policy and advisory boards of each center; volunteering services, facilities and equipment. These representatives provide a significant amount of matching funds and help to set the priorities for specific research and development work.

Federal and State funds earmarked for technology training, include computer literacy in the schools and the upgrading of mathematics and science skills of the public school teachers.

An estimated $180 million will be made available over the next 3 years for new investment due to the recent 10 percent reduction in the corporate net income tax in this State.

The Pennsylvania Industrial Development Authority (PIDA) serves the needs of business expansion by offering low-interest loans. In addition, it also provides additional incentives for firms with fewer than 50 employees.

A Pennsylvania capital loan fund was created from funds of the State-controlled Federal Appalachian Regional Commission (ARC). This year $15 million in State funds was earmarked to supplement ARC dollars over the next 3 years.

A recent State law which greatly improves venture capital availability, is one which permits the use of up to 1 percent of the State public school employees retirement funds for venture capital investments. This initiative is expected to provide up to $100 million in additional venture capital in the State. Utah, California, and a number of other States have recently passed similar legislation.

This spring, Pennsylvania voters approved a $190 million bond issue to fund a variety of new initiatives, such as providing loan assistance to employees who wish to buy out firms that otherwise

would close or move elsewhere and increasing aid to the Pennsylvania Minority Development Authority.

In general, the Utah, North Carolina, and Pennsylvania experiences suggest that the "State high-tech movement" represents a fresh approach to economic development by many States and regions. The State high-tech strategies examined in this chapter are based upon a number of guiding principles which include:

1. An emphasis on building links between industry and academe;
2. A strong commitment to improving the quality of human capital through education, training, and research;
3. A recognition that research and advanced technology can help to improve the competitiveness of existing firms and industries, and develop new firms from existing industries;
4. The belief that the private sector must have a lead role in the design and implementation of high-tech strategies;
5. An awareness that most new job growth will come from existing businesses and industries within the State; and
6. Recognition that a successful economic development program will require a long-term commitment to improving a State's climate for entrepreneurship and innovation.

A number of proponents of the now defunct national industrial policy movement have argued that States, not the Federal Government, should have responsibility for developing a "targeted" industrial policy for the States. If all States pursue industrial targeting, the sum of their efforts could be called a State implemented national industrial policy. Recently, the State of Rhode Island launched its version of a centralized "targeted" industrial policy and it was resoundly defeated by the voters. Yet, while the Rhode Island experiment was failing, Utah, North Carolina, and Pennsylvania, and many other States and regions, were winning popular support for their innovation strategies. Their strategies, unlike the Rhode Island example, emphasize "targeting the process of innovation" and shun strategies that would have State and local government officials "pick winners and losers" in a gigantic new industry subsidy game.

Summary and Conclusion

An analysis of the locational requirements of high-tech companies revealed the locational environment of high-tech complexes, such as the Silicon Valley in California and Route 128 in the Boston region. Many States and regions are attempting to create an innovative climate similar to that which is found in these two premier high-tech centers. For example, analysis of the high-tech strategies of Utah, North Carolina, and Pennsylvania revealed that the primary focus of State innovation strategies is on removing labor market, technological, and financial barriers to innovation and business expansion.

The States have not given up their well-entrenched practices of "smokestack chasing and deep locational subsidies." Economic studies have repeatedly found that locational grants and other job pirating strategies have little or no effect on the course of regional development. To the extent the States merely stamp their old development policies with a high-tech label and attempt to relocate

the Silicon Valley or Route 128, they will not be successful. "Persuading an established company to move from one location to another is a zero-sum game with no net gain for the Nation," said one Governor at the 1984 National Governors' Conference. In the words of Peter J. Brennan:

> Understanding the distinction between transplanted and innovative technology is an essential key to well planned area development programs. The first brings prosperity but not roots; the second is seed for a future built on products that do not exist or are yet a tiny factor in the economy.[11]

The experiences of Utah, North Carolina, and Pennsylvania suggest that State and regional development strategies are undergoing fundamental change. The focus of their high-tech strategies is inward on policies to create an innovative environment that is conducive to business startups, expansions, improved process and product technologies, and the development of new industries. While the efforts of individual States and regions may seem to be insignificant, in the aggregate they are substantial.

To the extent that the States and regions are successful, in their new endeavors, the Nation stands to gain substantially from having an improved climate for entrepreneurship and innovation. States are pursuing inward-looking innovation strategies because they are beginning to realize that most future job growth within their region will come from the expansion of existing firms and from new entrepreneurial startups. In this regard, the proper role of the Federal Government is to pursue a "hands off" policy regarding any attempt to use its vast resources to direct State and local development efforts. This would include eliminating Federal Government support for State and local industry subsidy and job pirating schemes, and curbing the abuses of tax exempt industrial development bond programs.

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[11] Peter J. Brennan, Testimony before the Joint Economic Committee, U.S. Congress, "State Innovation Strategies," Aug. 9, 1984, p. 41.

VI. VOICE OF THE ENTREPRENEURIAL COMMUNITY

Silicon Valley in California and Boston's Route 128 are vibrant centers of high technology that have captured world attention. What are the reasons for the tremendous success, economic growth, and prosperity that have characterized these laboratories of high-tech development? Can these same successes be achieved elsewhere? To find the answers to these questions, the Joint Economic Committee held hearings and toured plants in Silicon Valley on August 27 and 28, 1984, and at Route 128 in Boston, on August 30 and 31, 1984. A great deal was learned about the entrepreneurial spirit, attitude, management style, motivational and incentive influences, and, most relevant to this study, public policy recommendations for advancing the cause of entrepreneurship in the United States.

Testimony was heard from 27 witnesses, and tours were made of 10 plants and facilities.

In this chapter we summarize the findings from those hearings, probing into the heart and soul of entrepreneurship and innovation. This chapter discusses the underlying motivational forces and incentive structures that have both created this flowering of high-technology development and that continue to nurture it. Most important, the chapter discusses important public policy issues that affect entrepreneurial development. Public policy recommendations are presented which can fuel entrepreneurship, not only in Silicon Valley and Route 128, but in other areas of the United States as well. These include not only positive recommendations for aiding entrepreneurship, but recommendations for removing barriers to entrepreneurship.

To understand the heart of entrepreneurship and innovation, one must first get into the mind of the entrepreneur. The entrepreneur is a peculiar being, peculiar in a creative and dynamic way. What motivates the entrepreneur?

Risk

A vast majority of the entrepreneurs that founded the many high-tech firms in Silicon Valley and Route 128 were previously employed in successful, established high-technology and electronics firms in the same locality. In fact, the corporate history of these regions can be pictured as an extensive genealogical family tree where one firm has given birth to another or several firms and, in turn, these firms produced their own offspring. There must be something about the entrepreneur that enables him to leave the security of current employment and venture into the insecure and precarious world of starting a business on his own. The core of the entrepreneurial spirit is that the entrepreneur is willing to take risks. The entrepreneur of today resembles the American pioneer

of yesterday; willing to leave behind a safe and stable existence for the chance for great personal achievement and growth and, in the process, to expand and enhance the well-being of the surrounding community.

Success, however, is not the typical outcome. In fact, failure is most often the case. Dr. C. Lester Hogan, Director and Consultant to the President, Fairchild Camera & Instrument Corp., in testimony in Silicon Valley, estimated that only 5, and at the most 10, out of every 100 firms founded in Silicon Valley succeed.

Hogan went on to point out that failure is a necessary purifying agent in our free enterprise system. The 90 or 95 firms that fail "should fail." It ensures that the most productive and efficient resources will percolate to the top and will be utilized to the greatest social benefit. Less productive resources will be rechanneled into more suitable uses. Although the entrepreneur may fail, the entrepreneur is no failure. The willingness to take risks, whatever the outcome, enriches the character of the risktaker, adds to his or her wisdom and is the impetus for the evolution and strength of the American economy. Moreover, one cannot justify the potential large rewards to both the venture capitalist and the entrepreneur if one takes away the risk of failure.

Innovation and Creativity

Entrepreneurs, particularly those in the field of high technology, are innovators. They forever search for more efficient processes and procedures, and for new and better products. The histories of Silicon Valley and Boston areas are filled with instances where individuals, feeling frustrated and creatively stifled, defected from their former company and sought to establish a new firm in order to develop some idea of theirs and bring it to fruition. The result has not only been the proliferation of new high-tech companies and products, but also the establishment of new markets and new industries. For example, the semiconductor industry gave birth to one of the most significant and revolutionary developments in high technology in recent years, the microprocessor. At the heart of every weapons system, telephone, or electronic toy, is the microprocessor. In fact, the microprocessor opened up a marketplace of personal and small-business computers. In sum, without the entrepreneur's willingness to take risks and drive for innovation, the success stories of Silicon Valley and Boston's Route 128 may have never materialized.

These characteristics—a relish for risk, innovation and creativity—acting alone, however, are not sufficient reasons for the great proliferation of new high-tech companies and their phenomenal growth. The willingness to take risks does not necessarily mean those risks will be taken; and the drive for innovation may not result in a move toward initiation. There needs to be a structure of legislative and regulatory incentives and a system of rewards that can encourage and facilitate action on the part of the entrepreneurial community. These public policy issues are discussed in the last half of this chapter.

Role Models

Role models play an important part in encouraging many entrepreneurs to establish new firms. They provide valuable lessons in management, marketing, and production techniques. The accumulated experience of the Hogans, the Noyces, and the Sporcks enabled many entrepreneurs to build on the foundation of these giants in the development of their own businesses. While the necessity of risktaking and creativity is vital to initiate a company and should not be understated, the need for building on the previous training and experience of others cannot be overstated.

Employee-Management Relations

One key factor responsible for the rapid development of technological innovation in Silicon Valley and Route 128 has been a distinctive and enlightened employee-management relationship. In fact, such a relationship has made these high-tech firms literally factories of innovation. There exists a unique blend of incentives and rewards which, combined with a stimulating work environment, have created phenomenal rates of productivity and technological innovation. As W.J. Sanders, Chairman and CEO of Advanced Micro Devices, said, "We believe that many of our sister high-tech companies are not only on the leading edge of technology, but also on employee relations."[1]

What is it about this type of relationship which breeds innovation and, in addition, has made the companies in these two regions some of the best companies in the country to work for?

The reasons are due, in part, to the nature of the high-tech industries. Such industries are extremely competitive and firms must constantly innovate and develop new products in order to stay alive. High-tech firms must provide incentives to attract and maintain a talented work force and to continually stimulate innovation and productivity.

To a certain degree, the competition in the marketplace for talented employees is as fierce as in the marketplace for the high-tech products themselves. In fact, in Silicon Valley, because of close proximity between high-tech firms, there is a not so facetious joke that an employee, dissatisfied with his or her job, can simply drive into the next parking lot and work there instead. Employee shifts are almost that easy and that common.

Innovation and Work Environment

The unique and progressive work environments in high-tech firms play a key role in their ability to stimulate innovation. In fact, innovation, to a certain extent, is the ultimate goal of the work agenda.

The basic underlying theme of the high-tech work atmosphere is, what can be called, the "human factor." After all, innovation cannot be mined from the ground, but is found in the minds of people. An atmosphere of innovation, therefore, must be oriented

[1] U.S. Congress, Joint Economic Committee, "Climate for Entrepreneurship and Innovation in the United States," Field Hearings in Sunnyvale (Silicon Valley), CA, Joint Economic Committee, 98th Congress, 2d sess., Aug. 27-28, 1984, p. 72.

toward people, because people produce innovation. It is this emphasis on the human factor that contrasts the high-tech work environment with that of other industries. As Charles Sporck, President and Chairman of the Board of National Semiconductor said, ". . . people are the whole ballgame in our business." [2]

Typical of the work environment of high-tech firms is a high degree of informality. There are no private offices (instead you see partitioned work space), no executive bathrooms, no reserved parking spaces, nor any of the usual amenities of a traditional corporate pecking order. While on the surface these may seem trivial, nevertheless, they symbolize an important attitude. That attitude is an emphasis on innovation, rather than corporate structure, a recognition that it is the hired hands—the engineers and scientists on the firing line—that are the creators of the firm's products, and often those products are simply ideas.

It is believed that the most fertile atmosphere for innovation is one where there is open communication and a free flow of ideas up, down, and sideways, and where each employee feels that he plays a role in the decisionmaking processes of the company. Sandra Kurtzing, Chairman and CEO of ASK Computer Systems, Inc., explains, "The atmosphere is collegial where all ideas are debated and the best ideas emerge. The result is a true team effort. The people orientation also goes beyond the tangibles. Employees act like owners because . . . they are owners."[3]

While top management continues to be the ultimate decisionmaking body, management and production decisions are not dictated from the top down. Rather, they are a synthesis of the free exchange of ideas in which every employee may have some input.

In addition to the informal work environment, many firms in Silicon Valley and Boston have built facilities which make working in these companies just plain enjoyable. Many have built gymnasiums and recreation parks which enable employees to unwind and relax so that they can free their minds for more creative and innovative ideas.

Venture Capital Community

The venture capital community plays an extremely important role in the proliferation and growth of high-tech firms. It provides the necessary capital to initiate numerous startups and supplies crucial additional capital for growth and development. In some ways, the entrepreneurial community and the venture capital community are inextricably intertwined.

First, venture capitalists do not merely provide money. In most cases the venture capitalists also take an active part in the management of the company. In an emotional and intellectual sense, they become coventurers. Venture capitalists often provide valuable management and business know-how and experience that can be critical to the success of the company, knowing that ventures of this sort are not short term. It often takes 5 years before any return at all on investment is generated and it may take even 10

[2] Ibid., p. 68.
[3] Ibid., p. 113.

years before a venture capitalist can sell his or her investment. Arthur D. Little of Narragansett Capital Corp. explains this long-term commitment of venture capitalists: "We have a company now that is doing about $70 million of business. We had to put money into that company 17 times before it finally showed a profit. We did question our judgement from time to time on that one, but you don't have that market that is going to give you the quick profit. So you have to have that long range patient view."[4]

Second, venture capital provides financial leverage for high-tech, high-growth companies. The typical startup company finances its initial investment by the use of debt instruments, such as bonds, loans, etc. But debt financing provides little benefit for new high-growth, high-technology firms. High-technology firms need substantial amounts of equity capital in order to fund research and to develop new products. A large pool of capital during those early years is crucial to a high-tech firm's viability. Debt financing would require that dividends and interest be paid out of that pool of vital initial capital, thus draining the company of critical financial resources from the beginning.

Venture capital helps the high-tech firms avoid this problem. Venture equity capital is long-term, direct investment in a company whose return is much delayed and depends on the growth and success of that company. During these first few important years, venture capital can supply the funds necessary for research and development, so crucial to the longrun viability of the company.

The venture capitalist's motives are not purely altruistic. The rewards from a winning investment can be very large indeed. True, there is substantial risk, and an entire investment can be lost, but a few good winners can usually more than compensate for the losing investments.

One interesting phenomenon in Silicon Valley and Route 128 is that often the venture capitalists will seek out talented entrepreneurs or hot ideas for investment, rather than wait for entrepreneurs to seek him or her out. At the Joint Economic Committee field hearing examples were cited where venture firms actually took part in the entrepreneurial act itself. They had ideas and assembled the talent, the money, and the organization to launch a new business. However, the typical case is the opposite—the entrepreneurs seeks out the venture capitalists.

Federal Policy and the Entrepreneur

At the Joint Economic Committee hearing in Silicon Valley and Boston's Route 128, a number of public policy issues surfaced that have an important bearing on the ability of the entrepreneur to succeed in promoting technological and economic advancement. As might be expected, most of these issues center on tax policy. This section addresses these public policy issues that are of greatest concern to the entrepreneurial community.

[4] Ibid., p. 310.

Capital Gains Tax

The most important of the tax provisions affecting entrepreneurs is the Capital Gains Tax. Because of the large risks involved in establishing a startup, there needs to be a strong incentive to induce the potential entrepreneur to take that risk. While a low-tax on capital gains may provide some incentive, a low absolute tax rate is not sufficient. The critical factor is the tax on capital gains relative to the tax on personal earned income. It is this differential between these tax rates which induces the entrepreneur to leave his or her secure, regular salaried income and attempt a high risk venture. The lower the rate on capital gains relative to personal earned income, the greater the incentive to accept the risk and to initiate the startup.

There have been some important changes in capital gains taxation in recent years. Under the 1969 Tax Code, the tax rate on capital gains ranged between 35 and 49 percent, the actual rate depending on eligibility for exclusions and alternative tax provisions. The 49 percent top rate on capital gains, under the 1969 code, was little different from the 50 percent top rate on personal earned income (which had been lowered from 70 percent to 50 percent in 1969).

Because the top tax rates on earned and investment income were virtually identical, there were little or no incentive to invest in young and growing companies. As a result, the number of new startups dwindled and the pool of venture capital almost dried up in the 1970's. In 1975, the total new private capital directed to venture capital firms was a paltry $10 million.

In 1978, the capital gains rate was lowered to 28 percent by raising the exclusion to 60 percent and lowering the inclusion to 40 percent (40 percent times 70 percent equals 28 percent). Then, in the Economic Recovery Tax Act of 1981, the capital gains tax was lowered to 20 percent as a result of dropping the top rate on unearned income to 50 percent (40 percent times 50 percent equals 20 percent). Thus, beginning in 1978, and more strongly in 1981, the investment pattern in new companies reversed itself. In 1978, the amount of total private capital increased each year thereafter and by 1983 it had jumped to $4.1 billion. Venture capital funds have been flowing profusely ever since.

Thus, the differential between capital gains rates and personal earned income tax rates is an important incentive mechanism to entrepreneurs. Prudent public policy would dictate that this differential be maintained if not increased further.

The R&D Tax Credit

The R&D Tax Credit has also had a significant impact on the growth of high-tech firms. High-tech industries are extremely competitive and, in turn, this fierce competition places tremendous pressure on firms to constantly innovate and develop new products. Constant innovation, however, requires continuous research. Research is imperative to the survival and growth of these dynamic companies. The R&D Tax Credit enables these firms to devote more of their earnings to research for technological innovation and the development of more products.

Unfortunately, the R&D Tax Credit provides little benefit to brand new startup companies. In general, startup companies do not make taxable profits in their early years; hence, the credits can do little to provide incentives for R&D. After the initial startup period, though, the R&D Tax Credit can be extremely beneficial to rapidly growing companies and can serve as a powerful incentive for research and development. In fact, the R&D credit provides proportionately greater benefits for rapidly growing smaller companies than for larger, established companies with slower growth. This is due to the nature of the tax credit provisions. The R&D credit is a function of *increased* R&D expenditures over a base period amount. Since small, rapidly growing companies make greater percentage *increases* in research and development spending relative to larger companies, they receive proportionally greater benefits from the R&D credit.

Witnesses at the Silicon Valley and Route 128 hearings recommended several changes to make the R&D Tax Credit more useful. First, reestablish the "safe harbor leasing" concept that would allow companies to sell the benefits received from the tax credit. In this way, small startups could benefit from the R&D credit in their early years. Second, the R&D tax credit schedule only allows use over a very short period of time. In order to provide greater incentives for long-term research and development, the schedule should be lengthened to enable firms to derive benefits from the credit over long base periods. Third, eliminate the rolling base restriction and base the measurement of R&D increases eligible for the credit on 1982 to 1984 average expenditures. Fourth, permit tax deductions for contributions of equipment for teaching science in universities, colleges, and vocational institutions. (There is already a provision for equipment donated for scientific research.) Finally, and most importantly, the R&D credit is scheduled to expire on December 31, 1985. Simple prudent answer: Make it permanent.

Incentive Stock Options

Undeniably, the most important incentive mechanism that high-tech firms use to both attract personnel and encourage productivity are incentive stock options, or "ISO's." ISO's are particularly important in recruiting needed management and engineering personnel. These skilled people are in great demand and, therefore, require strong incentives to persuade them to leave secure employment in an established firm for an insecure future in a new one. In a majority of the high-tech firms in Silicon Valley and Route 128, it is not uncommon for ISO's to be extended to all employees in a company, thus appealing to the entrepreneur spirit in everyone. Each employee is a partial owner in the company, and as a result, each person in the firm has a stake in its future growth and success. This is a great boon to productivity in high-tech firms. The greater the rate of growth the company experiences, the greater will be the appreciation of the firm's stock and, consequently, the greater the value of the option. Thus, each employee has an incentive to be as productive as possible and contribute his or her fullest to the success of the company.

Another reason ISO's have contributed to the success of these high-tech firms is that ISO's serve as an effective personnel recruiting mechanism, without using up previous cash needed for research and development for promoting long-term growth.

According to Bureau of Labor Statistics data, high-tech firms are not always high-paying firms. While wage scales are slightly above the national average for the total private sector, they are below, sometimes substantially below, wage scales in many industry groups—motor vehicles and equipment, petroleum refining, paper and allied products, primary metal, construction, mining, and a host of others.

These high-tech firms would never be able to attract the necessary talent were it not for the ISO's and other noncash benefits, such as medical and dental insurance programs.

There are some problems, however, with ISO's that need correction. First, the attractiveness of ISO's is severely diminished by a ceiling of $100,000 (at fair market value) on the allowable amount of options that can be granted to an employee in 1 year. This $100,000 annual ceiling is arbitrary and creates a disincentive for employees to participate in the ISO program. Second, the "spread" between the exercise price of the option and the fair market value is treated as a tax preference item in calculating the alternative minimum tax. Under these provisions, someone exercising an option can be subject to a 20 percent tax on a paper profit and, in addition, be subject to capital gains tax at the time of sale. The result is double taxation of what may very well be a capital loss. Third, ISO's must be exercised in the order of sequence in which they were granted. This rule greatly reduces the benefit of ISO's, particularly if the exercise price of the options granted earlier exceeds the current market value or those granted have an exercise price lower than fair-market value.

Alexander d'Argeloff, President of Teradyne, Inc., of Boston, poignantly expresses the concern of the entrepreneurial community concerning the problems of the incentive stock options: "Putting it all together . . . we've been crushed under the weight of endless tinkering and our publicly held companies have lost the benefit of one of the most brilliant and least costly incentive schemes ever devised." [5]

The appropriate policies are self-evident. Eliminate or raise the artificial ceiling on the allowable amount of ISO's that can be granted per year. Amend the Tax Code to eliminate the option "spread" as a tax preference item. Last, amend the Tax Code to delete the provision concerning sequential ordering of exercising options.

Additional public issues that are of interest to the entrepreneurial community, and came up for discussion in the JEC field hearings, are the following:

High-technology products have been an important component of U.S. exports in a market that is extremely competitive. It is imperative that U.S. high-tech exports be allowed to flow freely if we are to maintain our competitive edge. Various factors, however, have

[5] Ibid., p. 276.

frustrated our ability to export these high-tech products and hav put the United States at a disadvantage in the world market place

One problem is the administration of export licenses. Waiting pe riods between requests for licenses and the ability to finally expor have been excruciatingly long. Witnesses in Silicon Valley tol painful stories of sales lost to other countries because other coun tries were able to act quickly and deliver their products speedily This is an administrative problem. The Commerce Departmen must undertake intensive efforts to reduce the time between expor license applications and the granting of licenses.

Another problem relates to our sensitive national security. Whil we need to place restrictions on high-tech exports with military value, the restrictions often prevent export of nonsensitive high tech products, which pose no threat to national security. The prob lem is the vague definition of military sensitivity. William Bowman, Chairman of the Board of Spinnaker Software Corp. of Cambridge, MA, illustrates this point. He said, "It takes as much effort for us to export 'Facemaker,' which is an electronic version of 'Mr. Potatohead,' as it does another customer to export software that builds missile trajectories." [6]

We are not critical of the stand of our military establishment in blocking high-tech exports having military value. But nonsensitive exports should not be caught in the crossfire. The definitions of "sensitive" high-technology products need careful analysis.

A third factor has been an extremely strong dollar on foreign exchange markets. Although a strong dollar is often a healthy sign, it has created problems for export industries, particularly high-tech industries. Because of the strength of the dollar, our high-tech products have become more expensive relative to high-tech products of other countries. This is an issue that goes far beyond the scope of this study, but it does need national attention.

Finally, the need for a talented and adequately trained labor force is crucial to the growth of high-tech industries. Because of the relatively low math and science skills of American students, compared to some of our foreign competitors, and because of the inadequate supply of needed technical talent, U.S. firms rely heavily on skilled, foreign talent. For example (and a common example), the vice chairman of Intel Corp. said that 75 percent of their engineers and scientists are foreign born. Witnesses at the field hearings said that recent efforts in Congress to require foreign students, who have graduated from American universities to leave the country for 2 years before returning, would have a traumatic effect on high-tech industries. However, there are some important immigration policy considerations that have to be weighted against this specific concern of the high-tech firms.

Conclusion

There can be no question that the vigorous spirit of entrepreneurship in Silicon Valley and Route 128 in Boston has provided the necessary impetus for the economic success of these regions. In the recent spirited discussions of a national industrial policy, the

[6] Ibid., p. 272.

voice of the entrepreneur has not been drowned out. The Silicon Valley and Boston successes were not planned. They are the direct result of a free enterprise system at work. In order to release its full potential, our free enterprise system must be coupled with an incentive structure that rewards risk and accepts failure. These should be the proper policy guidelines.

Our vibrant free enterprise system and spirit of entrepreneurship and innovation should dictate the direction of economic development in this country, not some shortsighted bureaucratic planning board, as called for by the industrial policy advocates. If Silicon Valley and Boston's Route 128 provide any indication of the direction of our economy, it is clearly onward and upward.

VII. SUMMARY AND RECOMMENDATIONS

This study concludes with a summary of research findings and discussion of public policy recommendations. The analysis and recommendations are based largely upon a series of Joint Economic Committee hearings and studies during 1983–84 period. The Committee heard from numerous business leaders, government officials and leading economists on issues and public policies that affect industrial innovation, technology transfer, and the entrepreneurial process. Committee staff studies on high-tech firm location decisions, robotics industrial policy, Federal procurement policies, and the Nation's venture capital markets have been published on these topics.

SUMMARY

This current study effort focuses on the Nation's overall climate for entrepreneurship and innovation. The vital role played by the entrepreneur in economic growth and technological innovation is stressed. The study examines how public policies impact the entrepreneurial process in America, and what the Government's role should be in fostering an improved environment for economic growth and technological innovation. A basic conclusion of the study is that many of the shackles that stifled entrepreneurial activity in the past several decades have been removed, at least partially. As a consequence, America is now experiencing an economic rejuvenation in its old and new industries as a result of a vibrant entrepreneurial community. Entrepreneurial expansion is broad based and can be found in old as well as new industries.

Entrepreneurs are defined in this study to include all risktakers in society who have the organizational skills and the means to assemble resources and technology to exploit new economic opportunities that are not generally apparent to other decisionmakers. Risk bearing, organizational skills, and foresight are the key attributes of entrepreneurs.

Entrepreneurship cannot be taught but it can be nurtured by public policies that improve the climate for innovation. Some recent public policy changes that are contributing to the current entrepreneurial activities are:

1. The rapid growth of venture capital and other forms of risk capital resulting from recent public policy innovations, such as the 1978 and 1981 capital gains tax reductions, and improvements in regulations governing the investment behavior of pension funds.

2. The complete turnabout in inflationary psychology after 1980 from one of high inflationary expectations to one of low inflationary expectations.

3. Deregulation of many domestic industries such as trucking, financial services, communications, and the airlines, resulting in many new entrepreneurial opportunities.

4. Recent changes in patent regulations to encourage technology transfer from Federal Government funded basic research by giving universities, small businesses, and not-for-profit organizations title to inventions.

5. Passage of the Stevenson-Wydler Act of 1980 which places greater emphasis on technology transfer from research in Federal Government laboratories, agencies, and departments.

6. Substantially lower personal and corporate tax rates as a result of the Economic Recovery Act of 1981, including a substantial simplification of depreciation schedules.

7. A new macroeconomic management philosophy in Washington which emphasizes stable growth in aggregate demand to reduce policy uncertainty and promote overall stability in the economy.

8. Continued strong Federal Government support for basic research at universities and in government laboratories.

9. Continued strong public policy resistance to domestic protectionists pressures in spite of a strong dollar and large trade deficits.

While these policies have helped to stimulate and sustain the current surge in entrepreneurial expansion and investment in the economy, the job is not complete. The current challenge is to continue the policies that are in place and working, eliminate or improve the policies that are in place but are not working, and initiate new policies to overcome remaining technical, labor market, and financial barriers to economic growth and innovation.

The importance of technological innovation to economic growth is stressed throughout the study. Technological innovation enters the economy in the form of new products and processes that increase productivity and improve the quality of life. Economic growth occurs as a result of entrepreneurial decisions to employ technology, capital, and labor in new combinations or in increasing amounts.

Technology exerts a powerful force over economic growth by strengthening the product competitiveness of industries and by raising productivity. Expanded international and domestic market opportunities result from an improved cost structure, product quality, and better organization relative to other nations competing in world markets. Moreover, additional market opportunities result from higher incomes associated with productivity growth, which allow for additional domestic economic expansion. If labor markets are flexible and real wages are allowed to adjust, and if government pursues appropriate human capital and resource development policies—including policies to improve the functioning of labor markets—the net result will be a rate of net job creation sufficient to meet the needs of all Americans willing and able to work.

The study emphasizes that innovation is a process that occurs in old and new industries. It undergirds and strengthens the basic foundation upon which economic progress depends. Innovation occurs in the public and private sectors and in the manufacturing and nonmanufacturing sectors. It results from the application of new ideas to organizing economic relationships and solving eco-

nomic problems. Above all, innovation is a process of economic change; it is not the outcome of economic change. Indeed, an innovation policy is one that should emphasize a "level playing field" upon which entrepeneurs in small and large, and new and old, companies compete to achieve their desired outcomes.

The analysis began by discussing the evolving nature of American capitalism. In the past decade or so, the American economy has undergone dramatic structural adjustments. As a consequence, today's economy is different from the economy of the late 1960's and 1970's. A before and after analysis revealed that today's economy is more: (1) energy efficient, (2) international, (3) service oriented, (4) technologically sophisticated, and (5) internationally competitive.

Not only has the structure of the American economy changed; the entrepreneurial character of the economy has changed as well. One consequence of increasing global competition, shorter product cycles and the emerging high-tech sectors has been an increased emphasis on product quality, service, and improved process technology in business planning. American businesses, while not ignoring shortrun concerns, such as stock prices, are rapidly shifting emphasis to longrun strategies such as market position, the role of technology, and dynamic competition.

While current economic events warrant optimism over the longrun competitiveness of the American economy the study nevertheless found several potentially serious deficiencies in the Nation's overall climate for entrepreneurship and innovation, including:

1. Saving and investment as a percent of gross national product in the United States is considerably below that of most other advanced industrial nations. The strong preference for current consumption over future consumption, reinforced by U.S. tax policy, remains as a major barrier to capital formation and technological innovation in the United States.

The U.S. Tax Code provides a heavy bias in favor of current consumption. In particular, the double taxation of saving and dividend income has created a large wedge between the rate of return of investments (approximately 12 percent) and the rate of return on saving (approximately 6 percent). Also, interest deductions on loans to finance consumer durables and purchases by credit cards provides a tax incentive to consume a larger proportion of current income. The result is a rate of capital formation for the Nation that is below the rate of capital accumulation that would occur if capital markets equated the public's preferences for current and future consumption at the margin.

2. Because the rate of capital formation is comparatively low, the United States' ability to reap the major benefits of technological innovation is also comparatively low. Many other nations—with higher rates of capital formation—are able to incorporate new technological innovations into their manufacturing and nonmanufacturing sectors at a faster rate than U.S. industries. This finding is partially attributable to the fact that in a dynamic economy the demand for new technological innovation is dependent upon the overall rate of capital formation.

3. High real interest rates are a serious barrier to long-term U.S. capital formation, productivity growth, and industry competitiveness. The recent tax reductions have significantly increased the after-tax rate of return on saving and investment but the large Federal deficit will continue to drain investment and risk capital away from entrepreneurial investments as the economy progresses through the mature stages of the economic expansion.

4. While the U.S. economy generally leads the world in basic research, commercial R&D in the United States as a share of total R&D spending is lagging. A continued expansion of commercial R&D concomitant with a higher rate of capital formation will be necessary to modernize U.S. manufacturing and restore its competitiveness in world markets.

5. The process of technology transfer in the United States has been, and remains, in spite of recent improvements, an important barrier to technological innovation. Technological innovation in the United States is a highly specialized process, but the various components of this process are haphazardly connected. Basic research is largely housed in American universities and funded by the Federal Government. Private industry, however, has primary responsibility for "picking and nurturing" the commercial fruit that germinates from new insights into nature, provided by basic research. As a result of a gap between industry and academe, the road for the development of a new technology starting from idea formation to a full fledged technology is long and uncertain. In the 1950's and 1960's, the gradual drifting apart of academe and industry served to lengthen the gap and increase uncertainty.

While recent years have witnessed a healthy recoupling of academe and industry, the formation of industry-university ties is only in its fledgling stage. Many barriers—imagined and real—between the university system and industry must be removed to improve the ability of American industry to maintain, and improve its technological lead in commercial markets—a must to sustain longrun competitiveness.

6. The U.S. is currently blessed with a high quality stock of human capital and dynamic labor markets that offer the economy a degree of flexibility and dynamism unparalleled in the world. Unfortunately, the quality of the educational processes has been allowed to erode in the past several decades, and the educational needs of disadvantaged youth and displaced workers have not been fully addressed. Without strong Federal Government support for human capital improvements, especially in the sciences and engineering, America's technological edge will be increasingly difficult to maintain and perpetuate. The entrepreneurial community will suffer as well since technological innovation is a major source of new entrepreneurial opportunities.

7. While the Committee hearings found substantial evidence that State and local governments in recent years have been adopting new policies aimed at "targeting the process of innovation," large sums of money are still being spent on job pirating and industrial location schemes which detract from the Nation's entrepreneurial climate. Because they result in higher State and local taxes, without providing direct national benefits, the overall effect of location-

al subsidy schemes is a lower overall rate of private sector inves ment.

State and local governments have major responsibility for educ tion at the elementary, secondary, and the university levels. Tl quality of the academic environment that they provide is an e tremely important factor in the Nation's innovation process.

Also, State and local governments control much of the Nation public infrastructure—roads, highways, ports, and airways—that necessary to promote private sector expansion. State and local go ernment regulatory policies also affect the speed and cost of bus ness development and the willingness and ability of financial inst tutions to assume a risky investment portfolio.

8. Finally, the Federal Government invests heavily in the deve opment of applied technology to meet the mission needs of Feder Government departments and agencies. The Department of D fense, National Institutes of Health, and the National Aerospac and Science Administration are the largest government consumer of technology. Many of the Government labs perform both basi and applied research, the results of which often have potentia commercial applications.

The Committee discovered through its hearings that the proces of technology transfer from government laboratories is cumber some and largely inefficient, despite recent important improve ments resulting from the Stevenson-Wydler Act of 1980. In particu lar, the highly centralized, bureaucratic structure of Federal de partments and laboratories mitigates against technology transfer in many cases.

The result of these deficiencies is an economy suffering from slow productivity and economic growth, notwithstanding the fact that the United States is generally acknowledged to lead the world in many areas of basic research. The essential problem is the lack of incentives within the private sector to turn new inventions into new and more efficient, products, processes, and other technologies. To overcome these problems, this section advocates policies to raise the rate of capital formation, improve technology transfer from government laboratories, improve university-business linkages, and accelerate commercial R&D efforts.

Policy Recommendations

The policy recommendations of this study are based upon an extensive analysis of the relationships between government and the entrepreneurial community. An important assumption throughout the analysis is that government cannot and should not attempt to direct entrepreneurial activities in the economy, because government expenditure, tax, and regulatory policies impact on the entrepreneurial process, creating an improved climate for entrepreneurship and innovation is rightfully the responsibility of national public policy.

The policy orientation of this study is long run. The study is concerned with the process of growth and development of the American economy, and with identifying the appropriate Federal role in promoting an improved climate for entrepreneurship and innovation.

It is important to note that the private sector cannot work effi-ntly without government, because the government performs ıy functions that are vital to the entrepreneurial process: re-ırch, defense, macroeconomic management, social policy, main-ning a legal framework, and trade policies are examples of gov-ıment inputs into the entrepreneurial process. It is equally im-rtant to note that if government oversteps its bounds in carrying t its proper functions in dynamic capitalism, market inefficien-s will occur and economic growth will be impaired.

The policy recommendations of this study are grouped into the lowing categories: capital formation, commercial R&D, entrepre-urial policies, human capital, university linkages, technology ınsfer, New Federalism policies, and domestic and international ıpetition.

Capital Formation

Capital formation occurs when investors invest in new plant ıipment. In an environment of investment growth, technological ıovation is stimulated. It is generally easier to incorporate new hnology into new machines and physical facilities than it is to grade existing technologies and plant and equipment. For this ıson, an accelerated rate of capital formation stimulates entre-ıeurial demand and demand for new products and process tech-ogies.

The study recommends the following government actions to raise overall rate of capital formation:

. *Remove or reduce the burden of double taxation of saving and estment.*—The current Tax Code offers a number of incentives to rease saving and capital formation. Individual Retirement Ac-ınts (IRA's), accelerated cost recovery, investment tax credits, l lower marginal tax rates (the maximum rate is currently 50 cent) are all credited with contributing to the strong investment nate in the United States in recent years. Nevertheless, public icy uncertainties, the large Federal deficit, marginal tax rates t are still too high, and high real interest rates remain as bar-s to capital formation.

To remove these barriers to capital formation the study recom-nds:

. *Monetary and fiscal policies that avoid shortrun fine tuning l place major focus on long-term economic growth.*—Removing icy uncertainty is an important factor in stimulating capital for-tion and innovation. This is because the most significant single or encouraging or inhibiting entrepreneurship is the health and dictability of the macroeconomy. An economy characterized by ge swings in aggregate demand does not provide the entrepre-ır with a stable growing market that is conducive to new busi-s growth.

. *A gradual reduction in the Federal deficit to reduce real inter-rates and allow the value of the dollar to find its longrun ue.*—To reduce the deficit, the study recommends a longrun ıtegy of holding Federal Government expenditures to no more n 18 percent of gross national product.

4. *Lower marginal tax rates through tax base broadening.*—A modified flat tax rate program could provide a significant stimulus to overall capital formation. The 1981 and 1982 tax programs made a significant step forward in reducing excessive taxation on capital investments, but they introduced differentials in effective corporate tax rates by type of investment. Tax base broadening would reduce the distorting effects of differential tax rate burdens. By lowering tax rates, overall capital formation would be stimulated.

5. *Expand the current IRA program to allow individuals to defer a larger amount of their otherwise taxable income.*—Increasing IRA exemptions to $5,000 per household would go a long way to removing the heavy burden of double taxation on saving and allow the market to increase the Nation's rate of capital formation.

Commercial R&D

The Federal Government should pursue policies to encourage commercial R&D, but it should avoid substituting government "targeted" strategies for reliance on market signals. Maintaining a healthy basic research community, providing incentives for commercial R&D, and improving linkages between basic and applied research activities can provide a viable alternative to direct government involvement in commercial research. It should be noted, the private sector will not invest optimally in applied research unless inventors are given adequate patent protection and other problems of nonappropriation are overcome. Appropriation problems result in a divergence, at the margin, of social and private benefits resulting from research. When this occurs, the market will fail to optimize investment and research opportunities.

The study recommends the following actions to encourage commercial research and technological innovation:

6. *The Federal Government should maintain strong support for basic research at American universities.*—Since basic research precedes applied research, maintaining strong Federal Government support for basic research is important. Technological innovation relies heavily on the progress and findings of basic research. Notwithstanding that basic research is becoming more and more valuable to commercial firms in its original form, it is still relatively long term in its scope. The traditional Federal role in supporting basic research, therefore, needs continuing support. The current Administration and the Congress have placed increasing emphasis on basic research, at a time when other budget increases are being curtailed. This priority on basic research is well placed, and will help keep this nation at the forefront of world technology.

7. *Congress ought to make permanent the current R&D tax credit and extend its base to include software development important to the application of technology within firms.*—At the present time, the R&D tax credit is not applicable to computer software R&D. This serious omission needs to be corrected if the R&D credit is retained in its present form. Additionally, the credit makes a distinction between the purchase of equipment for a university for the purposes of research, and for teaching purposes. Since this distinction is often impossible to make, and since there is a close correla-

tion between a university's teaching and research missions, this distinction should be eliminated.

8. *Preserve the tax advantage of R&D partnerships, particularly when they are used to encourage joint research efforts.*—The growth of R&D partnerships has been a significant vehicle for raising the level of commercial research in the United States. Also, as will be discussed later, the R&D partnership approach has promoted technology transfer and collaborative research efforts between industry and academe.

9. *Efforts to adopt antitrust laws to current economic realities need to be continued.*—The study applauds the current Administration and the Congress for their efforts in adapting the enforcement of antitrust laws to modern conditions. However, changes in the basic antitrust legislation are needed. The Sherman, Clayton, and Federal Trade Commission Acts, which still comprise the Nation's basic antitrust legislation, were signed into law more than 70 years ago. Last year, the Congress passed the National Cooperative Research Act. This law made substantial improvements in the climate for industrial basic research, by clarifying the standard for competing firms so that they could benefit collectively from cooperative research. That law, however, was part of a broader proposal, the National Productivity and Innovation Act, which would also have removed barriers in the patent laws, among others. Additional attention needs to be given to refining these proposals in the 99th Congress.

Entrepreneurial Policies

An overall strategy to increase economic growth through stimulating saving, investments, and technological innovation ought to be accompanied by policies to facilitate structural changes within firms and among industries in the economy. For this reason an economic growth strategy ought to incorporate among its components an entrepreneurial policy.

Entrepreneurial activities flourish in a time of economic change. Indeed, they are the internal mechanism by which the economy is transformed and shaped by changing external and internal forces, such as international competition, technological change, and changes in consumer preferences. Providing an environment whereby capital formation and technological innovation are flourishing as discussed, is the most significant action Government can take to improve the overall entrepreneurial climate.

Nevertheless, beyond these policies a number of additional initiatives would be helpful:

A significant proportion of entrepreneurial activities consists of seeking technological opportunities that others overlook or fail to fully recognize for their full commercial potential. A strong Federal commitment to basic research in the advanced sciences, discussed previously, is necessary to create new high-tech entrepreneurial opportunities.

Entrepreneurial high-tech opportunities are too risky for institutional investors to consider, but fortunately, venture capital markets have expanded to fill the void caused by the increasing institutionalization of financing markets. A recently published JEC study

on "Venture Capital and Innovation" found that networking and the availability of venture capital is a significant factor in the overall climate for technological innovation. Both the number and quality of high-tech entrepreneurial deals was found to increase as a result of expansion in venture capital following the 1978 and 1981 capital gains tax reductions.

Because of the importance of venture capital and other forms of risk and investment capital to the entrepreneurial process, the study recommends the following actions:

10. *Preserve the capital gains tax differential in the Tax Code to encourage risktaking.*—The Kemp-Kasten bill would provide this needed incentive while at the same time it would greatly simplify the Tax Code and lower marginal tax rates on income. For these reasons, the study recommends the adoption of the Kemp-Kasten program and it rejects the Treasury plan and the Bradley-Gephardt plan as they now stand.

11. *Improve incentives in the Tax Code to help entrepreneurial companies attract the needed talent.*—Being able to attract talent is the number one problem of high growth, young entrepreneurial companies. To overcome this problem, the study recommends changes in incentive stock options as an inducement to entrepreneurial growth. Specifically, the ceiling, sequencing and tax preference provisions should be eliminated or modified.

12. *Also, the tax exempt status of employee educational fringe benefits should be maintained in the Tax Code.*

Human Capital

The progress of science and technology, and its potential for improving our standard of living, depend in the first instance on society willing to invest in the human resources that underlie our technological preeminence. Yet the state of today's science and engineering education, starting at the secondary school level, leaves much to be desired. Some have proposed a new Morrill Act. Other, less sweeping, proposals call for higher standards in the teaching of science and mathematics in secondary schools, and changes in the treatment of gifts of equipment for teaching. (See above.) The study notes that the current Administration and the Congress have placed special importance on the upgrading of basic science and math skills in the primary and secondary schools and in the university system. These efforts to improve human capital should be continued and reinforced with new initiatives that:

13. *Provide scholarships and other incentives for brighter students to enter the science and engineering fields in college and beyond.*

14. *Establish a nationwide program to make nonsubsidized loans available to all college students without regard to family circumstances.*—The principal and interest would be collected by the IRS through withholding when the loan recipients enter the labor market.

University Linkages

The Federal Government ought to pursue policies to encourage and promote stronger linkages between academe and industry. Policies in place that are already encouraging these linkages in-

clude preferential tax treatment of R&D partnerships, granting universities title to patents resulting from federally funded research, NSF funded university research centers, the inclusion of 65 percent of contract services with universities in the incremental R&D tax credit base, and tax deductions for equipment grants to universities for purposes of research.

The study recommends that these policies be maintained and the following few initiatives be implemented:

15. *Extend the R&D tax credit for contributions of equipment for the teaching of science in universities, colleges, and vocational schools.*

16. *Encourage Federal departments and agencies to engage in collaborative research with universities and industry.*—The collaborative performance of the basic research needed to support Federal department and agency mission requirements could lead to the emergence of "centers of excellence" within academe, strengthen the Government laboratory system, and speed the commercialization of new technologies.

17. *Encourage joint university-industry research through a continuation of preferential tax treatment of R&D partnerships when the university is a partner in the joint venture.*

Technology Transfer

Federal Government laboratory research is legally available for use by the public. In practice, however, there are few incentives to utilize Federal patents and other research findings. This stems from certain provisions of patent laws, and the large amount of resources required for tracking and following through on Federal research.

Under the mandate of the Stevenson-Wydler Technology Innovation Act of 1980, Federal laboratories have made significant efforts to inform the public about developments in their research programs. However, for the most part, technology developed in Federal laboratories remains underutilized in the private sector.

To improve technology transfer, the study recommends the following:

18. *Decentralize authority and responsibility for technology transfer by making technology transfer a Federal laboratory responsibility, subject to review by Federal departments and agencies.*—The study recommends that the Office of Research and Technology Applications be a full-time staff position, with responsibility for networking with the business community, defining conflict of interest rules, acting as legal council for laboratory employees, and establishing policies for rewarding employees for successful technology transfer programs.

19. *Establish a Commission for Technology Transfer to develop operating guidelines and procedures for laboratory directors, engineers, and scientists to work collaboratively with universities and the private sector.*

20. *Federal Laboratory Consortium—a voluntary association of Federal laboratories—should be designated as the primary coordinating organization for promoting technology transfer.*

New Federalism Policies

In recent years, State and local governments have made encouraging strides in reorienting their development strategies to focus on the process of innovation. Many States are changing their tax, regulatory, and expenditure policies to encourage entrepreneurial activities and technological innovation. This revamping of development practice is largely in response to competition pressures among the States and regions for economic development and jobs.

The study recommends a Federal Government "hands off" policy with regard to the design and implementation of State and local development programs. However, the Federal Government has a role in discouraging those State and local activities that detract from the Nation's overall climate for entrepreneurship such as job pirating and industry locational subsidy schemes. Industrial development bonds are frequently used as locational inducements at the State and local levels.

To overcome this deficiency and to encourage State and local governments to focus on the process of innovation, the study recommends the following:

21. *Discourage the use of industrial development bonds by eliminating their tax exempt status.*

22. *The New Federalism policy of consolidating block grant funds and returning responsibility for regional economic development to the States ought to be continued.*—The Federal Government ought to maintain financial responsibility for those programs such as welfare and training displaced workers, in which there is a national interest.

Domestic and International Competition

Finally, because competition among firms and industries is vital to the entrepreneurial process and to the economic growth and prosperity of the Nation, a vigorous policy to promote competition, at home and abroad, must receive top priority in the decades ahead. In particular:

23. *The deregulation of domestic industries should remain as a national economic goal.*

24. *Open and free trade policies ought to be strongly supported and fought for by the Administration and the Congress.*

25. *Efficiency in the granting of export licenses must be improved so that American firms can get an early start in competing in international markets.*

26. *Foreign nationals with skills in occupations where there are shortages should be allowed to remain in the United States for a time.*

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