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THE U.S CLIMATE FOR ENTREPRENEURSHIP AND INNOVATION

A STUDY

PREPARED FOR THE USE OF THE

JOINT ECONOMIC COMMITTEE
CONGRESS OF THE UNITED STATES

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LETTER OF TRANSMITTAL

DECEMBER 24, 198

To the Members of the Joint Economic Committee:

I am pleased to transmit a study on "The U.S. Climate for En preneurship and Innovation." The authors are Dr. Robert Prem former staff economist; Dr. Charles Bradford, assistant director a senior economist; George Krumbhaar, staff economist; and Wei Schacht, Science Policy Research Division, Congressional Resea Service. This study is based upon a series of Joint Economic Cc mittee hearings on entrepreneurship and innovation, chaired Congressman Daniel E. Lungren.

The study recommends a series of public policies to improve t Nation's overall climate for entrepreneurship and innovation. T central feature of these policy recommendations is that they a aimed at increasing risk taking, saving, and capital formation. T policy recommendations are industry neutral in that they "tar the process of innovation," not specific firms and industries. An i plicit assumption of the study, of which I am in total agreement, that technological change and entrepreneurship are as importa to the old, established industries as they are to the young, ent preneurial companies.

The views expressed in this study are those of the authors, a do not necessarily represent the views of the authors' respective c ganizations, or the Joint Economic Committee or its members.

Sincerely,

ROGER W. JEPSEN,
Chairman, Joint Economic Committee.

FOREWORD

By Representative Daniel E. Lungren

In 1921, what has become the second longest running oil find the United States was discovered at Signal Hill, CA. People attr ed to the development of that oil frontier came from all parts the country. Some of these "wildcatters," as they became kno struck it rich, others were not quite as successful. The one th which they shared was a pioneering or risktaking attitude.

That entrepreneurial spirit which overtook Signal Hill has ma fested itself in various forms throughout our Nation's history. I symbolized by examples ranging from the covered wagon go west, the story of millions of immigrants who came to our coun seeking opportunity, and the "flying contraption" invented by Wright brothers, to the current technological revolution in vari places around the country. Although the frontier today has shif from land and oil to ideas and intellectual properties, the m actor, the entrepreneur, has continued to be the driving force. history documents, an essential part of the American fabric l always been our country's ability to innovate. Additionally, one our greatest resources has been the entrepreneur.

Entrepreneurs have often faced incredible odds in reaching th goals. The challenges confronting our Nation today are no exc tion. To some extent, the United States faces a different landsc than it did just a couple of decades ago. However, there is conc today that the American climate for the entrepreneur and for f tering innovation has not been all that it should be. Among m traditional labor, technical, and financial barriers, governm policy has often stood as a significant hurdle. Unless we can fos entrepreneurship and innovation by removing policy and econon barriers we may risk losing our technological and economic le At stake lies the opportunity to maintain our country's technolo cal leadership, improve our international competitiveness, a raise the quality of life and standard of living for our people.

Amidst the search for finding more productive ways of mainta ing U.S. competitiveness, some have sought solutions from abro In the 98th Congress, the industrial policy proposal raised the iss of what the proper role of the Government should be in the eco my. While this question was legitimate and important, the conc sions reached were misguided. The focus of the debate was on creasing central planning through an industrial policy board bank, which was based partially on an erroneous assumption th Japan attained much of its economic success through its Minist of International Trade and Industry.

Regrettably, much of the discussion over a national industri policy has been too quick to look at the superficial success of oth countries while neglecting our own strengths. This persistent "lo

over the shoulder" approach has led to what I call the "let's copy Japan, who first copied us" syndrome.

While we should never close our eyes to alternative approaches, we should not, at the same time, neglect what has worked successfully in the past. By disregarding our own economic and technological strengths, we allow other countries to develop ideas that originated in the United States. Thus, we allow the fruits of our ingenuity to slip through our fingers. The fact that the climate for the development and marketing of many of these ideas is better in other countries accounts for a large part of the problem. While there have been other centers of innovation, during the past quarter of a century, two primary regions have become recognized for spawning a technological revolution. They have become known as Silicon Valley and Route 128.

The growth in these two areas represents the merging of science and technology and the marketplace. Both regions illustrate what can happen when the fruits of basic research are used to create new technologies, products, and innovations. Regis McKenna, Regis McKenna Public Relations, described this development as it occurred in California:

> Silicon Valley is more than a place; it is a phenomenon . . . (It) is a symbol of innovation, growth, entrepreneurship, the prosperous future of high technology and the coming of the age of information . . . (Silicon Valley) is educating the rest of the world on how to survive in the 21st century.

As part of the inquiry into the process of innovation and entrepreneurship, the Joint Economic Committee held four days of field hearings in Sunnyvale, CA, and Boston, MA, to look at the Silicon Valley and Route 128 experience. These hearings represented the first attempt to analyze, comparatively, the entrepreneurial environment in the Nation's two premier high-tech centers. The primary concern in these hearings was to examine what guidance for public policy is held in the phenomenal success of Silicon Valley and Route 128.

As the report elaborates, there are a confluence of factors which can be identified as integral to the development and success of both Silicon Valley and Route 128. Making up part of the infrastructure to spur and support the process of innovation in these areas are the educational, marketing, mobile labor supply, management, and skill base. Among others, the importance of role models and access to venture capital were cited as critical factors.

Admittedly, inclusive among these factors was an element of randomness. A couple of witnesses suggested that perhaps the primary reason behind the geographic location of these two centers was attributable to historical accidents. Dr. Robert Noyce suggested that the base for Silicon Valley was established because the inventor of the transistor, William Shockley, grew up in Palo Alto. George Scriotis, former Secretary of Economic Affairs in Massachusetts, attributed, in some part, the development of Route 128 to happenstance.

While this report notes, and each of these witnesses suggested, that there is more to explaining the Silicon Valley and Route 128

phenomena than happenstance, this random element cannot be entirely overlooked. Indeed, it raises some valuable insights for public policy. What it suggests is that as a policy premise government should not target *specific* industries or areas. But the presupposition that government policy should not specifically target does not by any means imply that there is not a role for the Government to play in fostering economic and innovative growth.

The testimony made it clear that the Government can interpose barriers as well as incentives which affect the process of innovation. Perhaps the best support for this contention can be found in the experience with modifications in the capital gains tax rate. Going back to 1969, the data clearly show that when the capital gains tax was increased, access to venture capital—essential to new enterprise development—dried up. The exact opposite resulted when the capital gains tax was reduced. For example, since the decrease in the rate resulting from the Economic Recovery Tax Act in 1981, new jobs, accelerated applications of new technology, an enhanced environment for innovation, and increased revenues have all resulted. In addition, 1983 was a record year for venture investment, largely due to the reduction in the capital gains tax.

The economic growth, increase in jobs, and greater revenues all argue for retention of a differential between the capital gains tax and treatment of ordinary income. This is a proposal which the Congress would be wise to heed in the debate on tax simplification.

Thus, while not directly targeting individual firms or selecting certain industries, government policy, by fostering a favorable environment, can either serve as a barrier or incentive to economic and innovation growth.

What then is the proper role for government? What conclusions or guidance for public policy can be suggested? First, a major emphasis of this report is that promoting economic growth is best achieved by fostering a competitive environment, *not* through attempts to plan or target the economy. An apt analogy was offered in testimony by Dr. George N. Hatsopoulos, Chairman of the Board of Thermo Electron Corporation. As he pointed out during the Boston hearings, a cloud chamber, which is used by physicists for experimental purposes, establishes an environment in which condensation results. One never knows precisely where the condensation, which is triggered by a particle, will occur. What is important, however, is that once the favorable conditions are established, the desired goal, while perhaps not always immediately obtainable, will result.

By contrast, it seems all but certain the Government would have failed if it had tried to plan a Silicon Valley or Route 128. However, both of these technology centers did benefit from the consequence of many government policies.

The lesson from these experiences as we head toward the 1990's is therefore clear. In direct contrast to central planning or targeting, government policy should instead focus on establishing favorable climate for innovation and entrepreneurship. By concentrating on the economic fundamentals and establishing a positive economic environment, we may not know precisely where entrepreneurship will be spurred or where the latest breakthrough will result. But without the environment for innovation and entrepre-

neurship, the risk, even for the risktakers, becomes almost prohibitive. Consequently, there is less of a likelihood that a flourishing of talents and spinoff of ideas will emerge.

Second, there was no doubt from the hearings held in Washington, Sunnyvale, and Boston that the "secret to success" in the process of innovation and entrepreneurship is people. However, too often in the past "the people factor" as it relates to economic growth is ignored in the committee and meeting rooms in Washington. Instead, the discussion of macroeconomic theory, while important, neglects the essential role of the individual. There is little doubt that our country has the resources and the ability to maintain our technological leadership. However, to preserve our competitive edge we will have to focus on policies which bring out the best in the individual or entrepreneur. Overlooking "the people factor" would be a grave policy oversight. To this end, the report advocates an incentive-based approach. Various incentive-based policies are explored, including a clarification and simplification of incentive stock options which permit many employees—including those at the lower and middle levels—to share in the benefits of their firm's success.

Third, it became clear from the hearings and tours of companies that if there is any single area where Japan has an advantage over the United States it is in manufacturing. There is little disagreement that our Nation still leads in the area of innovation. The consequence of this, however, is that many of the ideas originating in the United States are developed in Japan since the Japanese have proven better in the past at packaging and marketing the product. In order to retain the fruits of our ideas, the United States will have to become more competitive in the manufacturing side of the equation.

Finally, government should not insulate companies from their own failures. As George Gilder has recently written "the knowledge—of inventors, entrepreneurs, producers, and consumers—which accumulates through the ongoing waves of human experience is the most crucial curve and capital of industrial progress. . . . Knowledge grows even when profits fall; and when profits rise, the learning process accelerates as entrepreneurs buy new experience by further investment and experiment." These views were echoed in the testimony of Dr. C. Lester Hogan, director and consultant to the president of Fairchild Camera & Instrument Corp. He indicated that as successful as Silicon Valley is perceived technologically, " . . . fewer than 5 percent of the entrepreneurial companies founded in Silicon Valley succeed. . . . it would be a terrible mistake for our government to attempt to save the 95 percent that fail."

Thus, from the seeds of the economic forces and government policy established throughout the past 25 years, the United States has been able to lead the world in the greatest technological revolution known to man. The consequence of policy today will impact the economy, jobs, quality of life, and technological leadership of our country as we enter the next century. The policy prescriptions suggested in this report offer some valuable suggestions for the outcome of each of these variables.

EXECUTIVE SUMMARY

The vital role played by the entrepreneur in economic growth and technological innovation is stressed in this study of the Nation's overall climate for entrepreneurship and innovation. In particular, 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 result of a vibrant entrepreneurial community, America is now experiencing an economic rejuvenation in its old and new industries. The entrepreneurial expansion is broad based and can be found in the service as well as the manufacturing industries.

Entrepreneurs are defined to include all risktakers in society who have the organizational skills and the means to assemble the resources and the technology necessary 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 climate for entrepreneurial activities are:

1. An expansion of venture capital and other forms of risk capital resulting from recent public policy innovations. The 1978 and 1981 capital gains tax reductions, revisions in regulations governing pension fund investments, and improvements in Securities and Exchange Commission regulations governing access to private and public equity capital, contributed substantially to improve availability of risk capital.
2. A complete turnabout in inflationary psychology in recent years from one of high inflationary expectations to one of low inflationary expectations.
3. The deregulation of domestic industries such as trucking, financial services, communications, and the airlines, resulting in many new entrepreneurial opportunities.
4. Improvements in patent regulations to encourage technology transfer from Federal Government funded basic and applied research.
5. A greater emphasis on technology transfer from research in Federal Government laboratories.
6. A lower tax burden resulting from the Economic Recovery Act of 1981, including lower personal and corporate tax rates.

7. A shift in emphasis away from shortrun macroeconomic policies toward a goal of stable growth in aggregate demand, to reduce policy uncertainty and promote overall stability in the economy.

8. The restoration of strong Federal Government support for basic research.

9. The continuation of open trading policies with the international trading community.

While these policies have helped to stimulate economic expansion in the economy, the job is not complete. The current challenge is to (1) continue the policies that are in place and working, (2) eliminate or improve the policies that are in place but are not working, and (3) initiate new policies to overcome remaining technical, labor market, and financial barriers to economic growth and innovation. Some of the important remaining barriers to entrepreneurial expansion include:

1. A high Federal deficit which is diverting capital market funds that could be used to finance entrepreneurial investments.

2. An underutilization of universities and government labs as agents of technology development and transfer.

3. The excessive use of direct loans and tax incentives to attract industry by State and local governments. State and local governments have pushed aside many constraints to entrepreneurial expansion, but their continued emphasis on job pirating is counterproductive from a national viewpoint.

4. A Tax Code that has become increasingly complex and unfair, resulting in distorting influences on saving and investment decisions.

5. An antiquated antitrust law system which makes it difficult in some cases for American firms to compete internationally.

6. A growing sentiment in America for protectionists measures such as tariffs and quotas.

7. An inadequate patent and copyright protection system for the inventor/entrepreneurs of society.

As a result of these entrepreneurial barriers, the American economy is suffering from a comparatively low rate of saving, capital formation, commercial R&D, and industrial innovation. A basic thesis throughout this study is that a multipronged policy approach is needed to address these and other deficiencies in the U.S. climate for entrepreneurship and innovation.

Study Methodology

Many studies of economic growth are narrowly focused on the economic growth aggregates such as capital formation, labor supply, and productivity growth. Considerable emphasis has been placed in these studies on the relative contribution of the factors of production to growth in real per capita output. This study is less concerned about tracing an equilibrium growth trajectory for the economy. Instead, it focuses on the process of economic growth and on the role of the entrepreneur in combining capital, labor, and technology to exploit new economic opportunities. Equilibrium is never achieved in a dynamic entrepreneurial economy because the very entrepreneurial acts that propel the economy toward a new

equilibrium also move the economy to a different plateau, or they interject new elements of disequilibrium into the analysis.

Growth in output, capital, labor, and technology are outcomes of the "process of innovation," rather than objectives to be achieved by economic policy. The role of government envisioned in this study is one of creating a climate for innovation so that the entrepreneurial process—the free market economy—can work efficiently.

An important assumption of the study is that free, unfettered markets ought to be relied upon to allocate resources and output of the private sector economy. This condition requires that government not impose its investment criteria in those sectors where the private sector is doing a good job.

Risktaking and innovation receive particular focus in this study because the entrepreneur as a bearer of risks and as an innovator is critical to economic growth in a dynamic economy. For this reason, the main focus of this study is on the process of innovation in which the entrepreneur is seen as the primary catalyst for long-term economic growth.

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 economic 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 entrepreneurs compete to achieve desirable outcome.

Much of the information in this study is based upon an analysis of a series of 1984 Joint Economic Committee hearings—including field hearings in the Silicon Valley and the Route 128 region—on the Climate for Enterpreneurship and Innovation in the United States.[1] These hearings, chaired by Congressman Daniel E. Lungren, examined the role of technology in the economy from the perspective of the entrepreneur. The purpose of the hearings was to identify the major incentives and barriers to entrepreneurship and innovation in the United States.

The analysis begins 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 in that it 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. 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 tech-

[1] U.S. Congress, hearings before the Joint Economic Committee, "Climate for Entrepreneurship and Innovation in the United States." Part 2. 2d sess., 98th Cong., Government Printing Office, Washington, D.C., 1985.

nology in business planning. American businesses have shifted from shortrun concerns, such as stock prices, to longrun considerations such as market position, the role of technology, and dynamic competition.

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. Rather, 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 efficiently without government, because the Government performs many functions that are vital to the entrepreneurial process: research, defense, macroeconomic management, social policy, maintaining a legal framework, and trade policies are examples of government inputs into the entrepreneurial process. It is equally important to note that if government oversteps its bounds in carrying out its proper functions in dynamic capitalism, market inefficiencies will occur and economic growth will be impaired.

The policy recommendations of this study are grouped into the following categories: capital formation, commercial R&D, entrepreneurial policies, human capital, university linkages, technology transfer, new Federalism policies, and domestic and international competition.

Capital Formation

Capital formation occurs when investors invest in new plant equipment. In an environment of investment growth, technological innovation is stimulated. It is generally easier to incorporate new technology into new machines and physical facilities than it is to upgrade existing technologies and plant and equipment. For this reason, an accelerated rate of capital formation stimulates entrepreneurial demand and demand for new products and process technologies.

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

1. *Remove or reduce the burden of double taxation of saving and investment.*—The current Tax Code offers a number of incentives to increase saving and capital formation. Individual Retirement Accounts (IRA's), accelerated cost recovery, investment tax credits, and lower marginal tax rates (the maximum rate is currently 50 percent) are all credited with contributing to the strong investment climate in the United States in recent years. Nevertheless, public

policy uncertainties, the large Federal deficit, marginal tax rates that are still too high, and high real interest rates remain as barriers to capital formation.

To remove these barriers to capital formation the study recommends:

2. *Monetary and fiscal policies that avoid shortrun fine tuning and place major focus on long-term economic growth.*—Removing policy uncertainty is an important factor in stimulating capital formation and innovation. This is because the most significant single factor encouraging or inhibiting entrepreneurship is the health and predictability of the macroeconomy. An economy characterized by large swings in aggregate demand does not provide the entrepreneur with a stable growing market that is conducive to new business growth.

3. *A gradual reduction in the Federal deficit to reduce real interest rates and allow the value of the dollar to find its longrun value.*—To reduce the deficit, the study recommends a longrun strategy of holding Federal Government expenditures to no more than 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 toward 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 "targetted" 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 correlation 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, investment, 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 were 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 others 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 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 a 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 include 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 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.*

CONTENTS

THE U.S. CLIMATE FOR ENTREPRENEURSHIP AND INNOVATION

By Robert Premus, Charles Bradford, George Krumbhaar, and Wendy Schacht*

I. INTRODUCTION

In his 1985 inaugural address, President Reagan emphasized that a "new industrial revolution" is in store for America. The one caveat is that the Federal Government must pursue the appropriate policies, including tax reform, to unleash the latent entrepreneurial energies within the American economy.

This study outlines the necessary set of public policies if the "new industrial revolution" is going to be more than a dream. The entrepreneur is at the centerstage of the growth-oriented public policy approach outlined in this study. The policies that are proposed are aimed at improving the Nation's overall climate for entrepreneurship and innovation.

Structural Adjustments and the Entrepreneur

The American economy is undergoing dramatic structural changes, but change is not a new phenomenon. We have seen our society evolve from an agricultural economy in its first century to a heavy industry-dominated economy in the second century, and now we are witnessing a shift to a service-oriented and high-tech information society.

One consequence of an information-intensive economy is that manufacturing jobs, while continuing to grow in numbers, will shrink as a percent of total employment while service and high-tech jobs will expand in their share of total jobs.

In adjusting to the shifts, however, attention must not be limited to the high-tech industries or to the old, mature industries, nor should the public policy debate be cast in terms of the services versus manufacturing industries. High-tech, services, and manufacturing industries alone cannot generate enough jobs to make up for the jobs that will be lost as a result of dynamic adjustments in the economy. Rather, the debate should focus on the entrepreneur and

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a broad range of public policies to raise the rate of technological innovation, capital formation, and human resource investments.

Structural shifts in the U.S. economy are necessary to improve competitiveness and economic efficiency. Without dynamic structural adjustments, the American economy will grow below its potential as a result of being "locked into" an inefficient industrial structure. Accordingly, government policies and business practices must be accommodative, not roadblocks, if we are to achieve rising living standards, and improved international competitiveness. In fact, the structural shifts are the basis of a new burst of energy for a dynamic economy. New entrepreneurial opportunities must be developed, or we will stagnate and lose competitiveness.

The entrepreneur is at the heart of structural change, and is a key factor in dynamic economic growth. Entrepreneurs—broadly defined to include risktakers in society whether they are associated with large or small organizations, public or private—by seeking out new investment opportunities, are the linchpin in the process of structural adjustments in a dynamic economy.

In a word, the American economy is becoming more Schumpeterian. In a Schumpeterian world, competition takes the form of new products and new processes and improved services. According to Schumpeter:

> The first thing to go is the traditional conception of the "modus operandi" of competition. Economists are at long last emerging from the stage in which price competition was all they saw. As soon as quality competition and sales effort are admitted into the sacred precincts of theory, the price variable is ousted from its dominant position. However, it is still competition within a rigid pattern of invariant conditions, methods of production and forms of industrial organization in particular, that practically monopolizes attention. But in capitalist reality as distinguished from its textbook picture, it is not that kind of competition which counts but the competition from the new commodity, the new technology, the new source of supply, the new type of organization (the largest-scale unit of control for instance)—competition which commands a decisive cost or quality advantage and which strikes not at the margins of the profits and the outputs of the existing firms but at their foundations and their very lives. This kind of competition is as much more effective than the other as a bombardment is in comparison with forcing a door, and so much more important that it becomes a matter of comparative indifference whether competition in the ordinary sense functions more or less promptly; the powerful lever that in the long run expands output and brings down prices is in any case made of other stuff.[1]

Well-defined equilibrium cost and demand curves are not relevant to economic decisions in dynamic competition. The environ-

[1] Joseph A. Schumpeter, "Capitalism, Socialism and Democracy," New York: Harper Colophon Books, 1942, pp. 84-85.

ment is one of keeping pace with market trends and seeking to gain a market niche in areas of comparative advantage.

The essential feature of competition in a Schumpeterian world is that decisionmakers, public and private, are confronted with changing economic, business, and social relationships that interact on one another in a complex manner such that the outcomes in the process are difficult, if not impossible, to anticipate with a reasonable degree of certainty. The key to successful economic development within a changing economic environment is to manage the process of change to the advantage of the economy.

In dynamic competition, firms think strategically about their long-term position in world markets and less on the factors that influence current stock prices and public opinion. Generally, economies of large scale and technological innovation play an important role in long-term strategic business decisions.

Study Outline

This study is organized to provide a detailed analysis of the many factors that affect entrepreneurship and the process of technological innovation. Chapter II discusses the importance of stable markets and fiscal policies in creating an environment for entrepreneurship and innovation. The contribution of technological innovation to long-term economic growth is stressed. Chapter III describes the role of universities in technological innovation. Strengthening the linkage between academe and industry is viewed as a preferred alternative to the creation of new federally funded "generic technology centers" for encouraging commercial innovation. Chapter IV examines the contribution of government laboratories to the innovation process. Incentives to encourage collaboration with industry and conflict of interest problems are discussed. Chapter V describes some successful State innovation strategies for promoting technological innovation. Chapter VI presents the voice of the entrepreneurial community—what makes the entrepreneur tick and what he needs from government to continue ticking as a force in innovation, productivity, and economic growth. The discussion on the voice of the entrepreneur is taken from the record of field hearings held by the Committee in late August in Silicon Valley, CA, and at Boston's Route 128. The study concludes with a summary and conclusions, including recommendations for Federal actions to make the environment for innovation more friendly.

Study Recommendations

The major general recommendation, or even more to the point, the major plea, of this study is that we not fall into the trap of the industrial policy advocates, calling for targeting of specific industries or firms for promotion or renewal. Rather, we should target the "process of innovation." Congress should not get involved in choosing between which industries are worthy of government assistance and which are not. Instead, targeting the *process of innovation* will create an environment which fosters new ideas, new companies, modernization of mature companies, and will achieve the objectives of economic growth and expanding job opportunities.

In this process, the entrepreneur plays a key role. It is the entrepreneur who serves as the catalyst and facilitator in technological advancement which, in turn, is the key to productivity and economic growth. But the entrepreneur cannot operate in a vacuum. He needs the proper environment and the proper assistance from the Government—not government meddling, but government provision of a sound environment for technological innovation.

A major assumption of the study is that a national entrepreneurial policy ought to be broadly defined to include capital formation, technological innovation, trade policies, labor market adjustments, and fiscal and monetary policies. In addition, it should include specific policies typically associated with entrepreneurial economics such as the capital gains tax differential, incentive stock options, Securities and Exchange Commission regulations, and other policies that affect technology transfer, risktaking, and business enterprise development. The essential point is that a strategy to improve the Nation's climate for entrepreneurship and innovation, if it is to benefit a broad range of economic activities, must encompass a wide range of policies that affect the various components of the Nation's total process of innovation.

Because entrepreneurial activities tend to flourish in an expanding economy, macroeconomic policy, particularly the orderly expansion of aggregate demand, is important to the entrepreneurial process. Economic expansion, in turn, is determined by a number of interrelated supply-side factors including capital formation, saving, technological innovation, and human resource development, all of which should be part of our entrepreneurial policy. In short, the full range of government tax, expenditure, and regulatory authority must be considered in a strategy aimed at "targeting the process of innovation."

Structural shifts in the economy, due to changes in consumer preferences, foreign competition, resource prices, and technological change are another major source of growth-oriented entrepreneurial opportunities. The expansion of new industries and improvements in the products and process technologies of existing industries are major sources of entrepreneurial activities in a dynamic economy. But old and declining industries also offer new entrepreneurial opportunities through reorganization, new technologies, and better management.

A major source of structural change—although not the dominant force—is international competition. Changing world trade patterns have resulted in a shifting U.S. comparative advantage to a greater reliance on exports of capital goods, agricultural products, military goods, chemicals, and other high-tech oriented products. At the same time, the high value of the dollar is affecting the adjustment of the American economy to world markets, causing larger trade deficits. For this reason, the discussion of a national entrepreneurial policy would be incomplete without addressing the issue of U.S. exchange rates, interest rates, and government deficits.

A wellspring of new entrepreneurial activities, particularly those that are oriented to expanding the technological frontiers of the American economy, is technical change. Because technical change interacts with so many other factors, such as capital formation, its precise contribution to national economic growth is impossible to

quantify. An important assumption of this study is that technological change is a dominant force in U.S. competitiveness and economic growth, but technical change generally does not occur in isolation from changes in the other economic growth determinants. In any case, technological change is important to the entrepreneurial process because it is the source of new ideas upon which entrepreneurial companies, old and new, depend.

Research and development is a vital input into the process of technological change in the American economy. Basic research is a process whereby original research germinates new concepts, or scientific knowledge. Research and development adds form and content to the new scientific concepts, which, when developed end use as new product and process innovations in the marketplace. For this reason, entrepreneurship and innovation are mutually reinforcing processes that result in new company formation, or technical change within existing industries.

As discussed, entrepreneurs are the agents of economic change in a dynamic economy. As capital formation, technological change and growth in labor expand the economic horizons of the Nation the optimum mix of investments will change, due to changes in preferences and dynamic comparative advantage. Economic growth and structural change are different dimensions of the growth process in a dynamic economy. Thus, a national economic policy that attempts to accelerate national economic growth, within the constraints of the preferences of the American public for current consumption relative to future consumption, is one that will emphasize capital formation, technical change, and the free mobility of resources among competing users.

The role of government in economic growth, as advocated in this study, is not the simplistic view that government has no role. The question is one of the appropriate role of government in the economic process.

While the policies advocated in this study do not pit high tech against traditional industries, or service industries against manufacturing, the study's recommendations offer the Nation hope for preserving a broad and strong industrial base. A strategy to encourage entrepreneurship and innovation, by stressing capital formation and technological change, will have its largest impact on R&D intensive industries. The fact that 95 percent of the Nation's commercial R&D is done within the manufacturing sector, which is also capital intensive, suggests that an entrepreneurial policy, as defined in this study, will benefit the "smokestack" industries as well as the high-tech firms.

Nonmanufacturing industries will also benefit from a higher rate of economic growth and technological change, since nonmanufacturing industries are major consumers of high-technology products and they benefit from larger national markets. Where would the banking and insurance industries be today without advances in computers, lasers, and fiber optic technologies. The fact is that all industries will gain from an improved national climate for entrepreneurship and innovation, provided the Government pursues policies to target the process of innovation and leaves it to the market to allocate the expanded pool of resources among competing industries.

II. U.S. ECONOMIC CHANGE, ECONOMIC GROWTH, AND INNOVATION

The goal of this chapter is to trace the trends of U.S. economic growth and productivity, and to debunk the theory that the United States is deindustrializing. It discusses factors that affect productivity and economic growth, and specifically, the factors that affect technological innovation. A summary and recommendations to stimulate long-term economic growth conclude the chapter.

LONGRUN U.S. ECONOMIC PERFORMANCE

Over the two decades, 1960–80, the U.S. economy did not perform well. At best, economic growth can be called "labored" and productivity growth was disappointing. Unemployment and inflation were on a stagflation roller coaster, rising to higher and higher peaks and troughs, both reaching peaks in 1980. Americans were becoming more and more disgruntled with the state of economic affairs and the 1980 election brought a new administration to the White House and the first Republican Senate in 26 years. Americans wanted a new policy direction. They were simply fed up with our economic malaise.

Tables I and II show the trends in the broad economic aggregates. Table I shows productivity growth rates (gross domestic product per employed person) for the United States and six other countries over the two decades, 1961–80, and over the last 3 years. It is a discouraging picture, at least up to 1980. We were outperformed across the board.

TABLE I.—PRODUCTIVITY (GROSS DOMESTIC PRODUCT PER EMPLOYED PERSON) ANNUAL RATES OF CHANGE, 1961–83

Country	1961–65	1966–70	1971–75	1976–80	1981	1982	1983
nited States	3.1	1.1	1.0	0.7	1.4	−1.2	2.5
anada	2.9	2.1	1.7	.4	.1	−1.4	1.9
ance	5.4	4.5	3.6	2.9	1.1	1.9	1.0
ermany	4.4	4.3	2.8	3.1	.4	.6	3.4
aly	6.1	6.4	2.1	2.8	0	−.4	−1.2
pan	8.6	9.4	4.1	3.9	3.4	2.0	1.4
nited Kingdom	2.4	2.8	1.8	1.6	1.9	3.8	3.2
Average, excluding United States	5.0	4.9	2.7	2.5	1.2	1.1	1.6

Source: U.S. Bureau of Labor Statistics.

TABLE II.—GROWTH RATES IN REAL GROSS NATIONAL PRODUCT, 1960–84

Country	1961–65	1966–70	1971–75	1976–80	1981	1982	1983	1984 (estimate)
United States	4.7	3.2	2.6	3.7	2.5	−2.1	3.7	6.5
Canada	5.7	4.8	5.0	3.1	3.8	−5.0	3.8	5.0
Japan	10.0	11.2	4.6	5.0	3.2	2.5	2.0	3.9
France	5.8	5.4	4.0	3.3	.2	1.5	.5	.6
West Germany	5.0	4.2	2.2	3.5	.2	−1.2	1.2	2.6
Italy	5.2	6.2	2.4	3.8	−.1	−.3	−1.5	1.9
United Kingdom	3.1	2.5	2.1	1.6	−2.0	.5	2.5	2.6
Average, excluding United States	5.8	5.7	3.4	3.4	.9	−.3	1.4	2.8

Source: Department of Commerce, IMF, OECD, and CEA.

Looking at total output, measured by real GNP, Table II shows that from 1961 through the mid-1970's, the United States trailed its industrial competitors, although the gaps are not as wide as in the case of productivity. The relatively better performance of GNP is due to a huge postwar "baby boom" in the United States, when strong labor force growth bolstered total output and helped to offset some of the decline in productivity per worker. But the general picture is the same. The United States was growing at a slower pace than the other nations.

Is the United States Losing Its Competitiveness or Deindustrializing?

This brings up a question. Does the slow U.S. productivity growth and slow economic growth of the 1960's and 1970's mean that the United States is losing its competitiveness in the world? Contrary to the opinion of industrial policy advocates, the answer is no.

The United States trails other nations in real GNP and productivity growth, but the fact that other nations lead in the economic aggregates is no sign the United States is not competitive in the world.

How should competitiveness be defined? Analysts have a variety of definitions. The one adopted in this study is, "the ability to expand markets abroad while increasing the real income of citizens at home." An important consideration in the competitiveness issue so defined is that the market expansion should not be done through currency changes.

Real GNP and productivity growth are not necessarily measures of world competitiveness. True, productivity is an important factor underlying a nation's longrun competitive performance. But the key point is whether an economy is expanding in keeping with its longrun growth *potential.* If it is performing below its potential, it is losing its competitiveness. If it is growing in lockstep with its potential, it is maintaining its competitiveness. If we had high investment but low growth, we definitely would have a competitiveness problem, but that is not the situation in the United States.

The longrun potential for growth depends on capital formation, based on saving and investment decisions. U.S. capital formation is

slower than that of other nations, and therefore, its potential for long-term economic growth is lower. This is *not* a sign of reduced competitiveness. U.S. industries are competitive within the constraints of relatively low capital formation. The central issue is whether the rate of capital formation is consistent with the preferences of the American public for long-term economic growth.

It is important to keep in mind that other industrialized nations have experienced recent slowdowns in output and productivity growth as well. In fact, GNP and productive growth suffered larger declines abroad. Thus, the relative position of the United States actually improved over the past 10 years.

In a related question, is the United States deindustrializing? Again, the answer is no. There are structural shifts taking place, and the relative position of manufacturing in the United States is declining, but U.S. manufacturing is still expanding overall.[1]

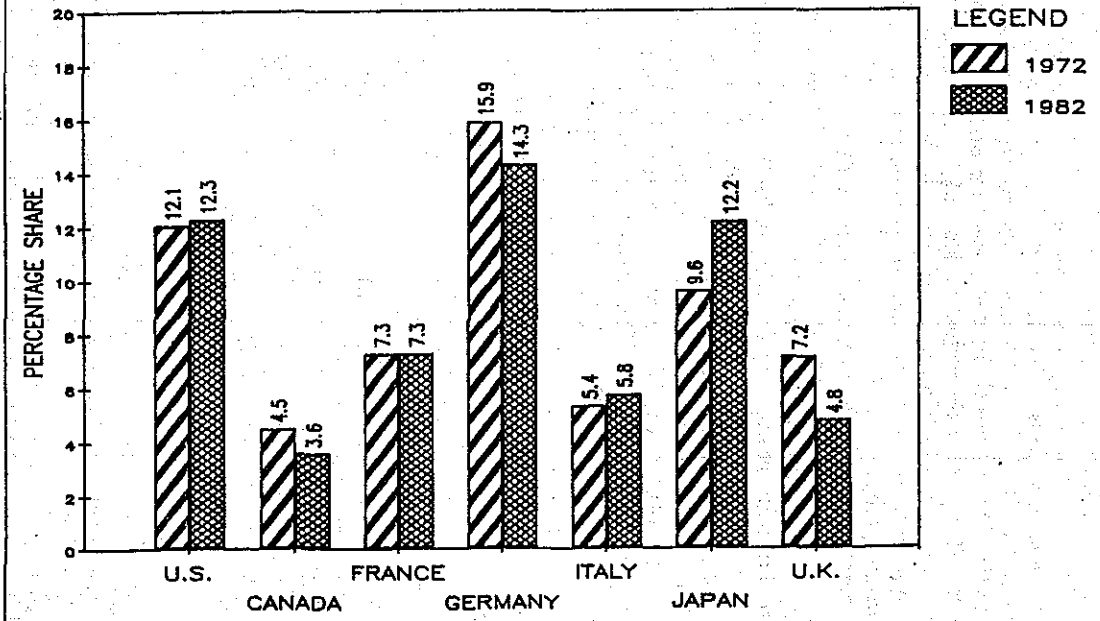
Regarding manufacturing output and employment, the United States fares quite well. Value added in manufacturing output has held relatively steady at about 24 percent of GNP since 1950, and the perception that millions of American manufacturing workers are being displaced by foreign competitors is simply untrue. Manufacturing jobs have increased every decade since the 1950's. When compared with the secular decline in manufacturing jobs in many European countries, the U.S. experience in manufacturing is quite impressive.[2] All industrial countries lost manufacturing jobs in the 1981–82 recession, but since the recession ended in November 1982, the United States has had the most dramatic job recovery of all nations.

Moreover, as a percent of world manufacturing exports, the United States is holding its own. Chart I, below, shows the world share of manufacturing exports in 1972 and 1982. The U.S. share has risen slightly from 12.1 percent in 1972 to 12.3 percent in 1982. Japan has risen sharply in its share of the world total, but this has been at the expense of Europe, not the United States.

[1] This subject is treated in some detail in: U.S. Congress, Joint Economic Committee, "Industrial Policy Movement in the United States: Is It the Answer?" Joint Committee Print, Senate Report No. 98–196, 98th Congress, 2d Sess., June 8, 1984, Chapter IV, pp. 25–39.

[2] *Ibid.*

WORLD SHARE OF MANUFACTURING EXPORTS SEVEN LEADING INDUSTRIAL NATIONS 1972–1982



SOURCE: NEW YORK STOCK EXCHANGE

What is happening in the American economy is that long-term structural changes are being reflected in rising fortunes for some industries and declining fortunes for others. Manufacturing *output* has kept pace with the national economy, and the world economy, but manufacturing *jobs* have been declining as a *percent* of *total* employment in the United States. These structural shifts reflect higher productivity growth in some sectors and shifts in consumer preferences. They do not reflect a loss of U.S. competitiveness in international markets. Foreign competition is important, but it is not a major causal factor in the long-term transformation of the American economy.

While service jobs have increased much faster than manufacturing jobs, manufacturing remains a dynamic source of employment opportunity for American workers.

Within manufacturing itself, some industries have been expanding and others have been contracting. From Table III below, it is clear that U.S. manufacturing is becoming more technologically sophisticated and skill intensive. The high-tech sectors increased their share of total manufacturing value added from 27 percent in 1960 to 38 percent in 1980. The heavy goods industries have declined in their relative contribution to value added in manufacturing.

TABLE III—SHARES IN U.S. MANUFACTURING VALUE-ADDED AND EMPLOYMENT

	Value-Added [1]					Employment [2]		
	1960	1970	1972	1973	1980	1972	1973	1980
Process:								
High technology	0.27	0.31	0.31	0.32	0.38	0.28	0.29	0.33
Capital intensive	.32	.30	.31	.32	.27	.30	.30	.28
Labor intensive	.13	.13	.14	.13	.12	.21	.21	.19
Resource intensive	.28	.25	.24	.23	.23	.21	.20	.20
End use:								
Consumer nondurables	.20	.17	.17	.15	.15	.19	.19	.17
Consumer durables	.03	.04	.04	.04	.05	.05	.05	.05
Automobile	.07	.06	.07	.08	.05	.05	.05	.04
Equipment	.19	.22	.21	.21	.24	.20	.20	.23
Intermediate products	.51	.51	.51	.51	.50	.51	.51	.52

[1] Value-added computed the 85-industry level 1-0 divisions by multiplying gross output in constant dollars by the ratio of value-added in output in the 1972 1-0 table.

[2] Employment numbers derived from the Bureau of Labor series on employment and earnings aggregated im the 2-digit 1-0 divisions and then to the process and end-use categories.

The high-tech sectors have also increased their significance as a source of jobs in manufacturing. The high-tech sectors increased their relative contribution in manufacturing jobs from 28 percent in 1972 to 33 percent in 1980. In general, the high-tech sectors are identified as being those most dependent on R&D inputs and highly skilled labor (scientists, engineers, and technicians).

From a national perspective, industry transformations add up to a more efficient industrial structure for the United States. Fortunately, the American economy is blessed with a high degree of capital and labor mobility that allows its industrial structure to evolve into an efficient pattern—as dictated by competitive markets—without causing severe structural-adjustment problems.

The conclusions in all of this are that: (1) the U.S. econom very dynamic, with the fastest economic growth of any indust country at the present time, although admittedly we did not form well in the 1960's and 1970's; (2) the United States *is* com ing in world markets; (3) America is not deindustrializing; anc the United States is not suffering from massive long-term struc al unemployment. There is unemployment, yes, and it is seriou some areas, yes, but it is not massive, and it is not getting wo Our record on this is better than that of our European competit The long-term unemployment rate in the United States is m lower than it is in the industrialized nations of Europe.

While we do not have a competitiveness problem, we do have economic growth problem. It is in the best interests of the Un States to improve on the growth performance of the past sev decades, not just to be a greater power in the world economy, to increase real incomes and living standards at home. Strong persistent economic growth is our greatest need.

What gives rise to economic growth? Two fundamental com nents:

1. *Growth in man-hours worked.*—The dominant component manhours worked, of course, is the size of the labor force. other determinants of man-hours are the employment rate, the erage length of the workweek, and the number of weeks worl per year.

2. *Growth in productivity.*—A measure of labor productivity output per worker per hour worked. Total man-hours worked a labor productivity give rise to the total output of a nation ove year's time (i.e., gross national product).

Labor Force and Man-hours Worked

Government policy cannot do a great deal to affect the size of t labor force which, in turn, is the major determinant in man-hou worked. The longrun growth in the labor force depends on su basics as birth rate, death rate, and the net immigration rate. N can government do a great deal to affect the labor participati rate. One of the most dramatic changes over the past three decad has been the substantial rise in the number of women in the wo force.

In 1954, only 34 percent of females 20 years and older were the work force. Today, that ratio is 54 percent, and rising. Wh knows how high it will go. Interestingly, the male participatic rate has *declined,* from 88 percent in 1954 to 77 percent today.

The U.S. labor force grew quite rapidly in the 1970's due to th post-World War II "baby boom." This has now ended, and over th next decade, labor force growth should settle back to its postwa average of about 1.8 percent per year, or more likely, 1.5 or 1.6 pe cent. Supporting these lower estimates, the Census Bureau's "mo erate" estimate is for population to grow 0.8 percent over the ne two decades, down from the 1 percent where it has been stuc since the baby boom ended in the late 1960's. Allowing for gradua ly rising labor participation rates, 1.5 to 1.8 percent is the max mum labor force growth we can expect over the next decade o

, That means growth in man-hours worked of about 1 percent, ybe 1.2 percent.

Productivity

hus, productivity will have to bear the major burden of economrowth in the United States over the next decade or two.
What affects productivity? These are some basics that most anas would agree on:
. Economic growth and stability. (There is a "chicken and egg" ergism here. Productivity is basic to economic growth, but the e and stability of economic growth also affects productivity.)
. Increased and improved capital equipment available to each ker.
. Technological innovation, primarily through research and deopment.
. Reduced government regulation.
. Improved labor quality and increased education and skill of work force.
. Improved entrepreneurial and management skills.
. Labor-management cooperation.
. Improved product quality.
. Labor and capital mobility.
0. Access to good land and natural resources.
here are others and there are many subfactors under many of se, but these are all basic to productivity growth.
s discussed earlier, and as shown in Tables I and II, U.S. protivity and economic growth performance were not very good in 1960's and 1970's. Why was this so? There are many reasons, ie due to private sector failings and some due to public policy ors. It is primarily the latter with which this study is concerned, ough some private sector faults will also be discussed.
irst, U.S. economic policy in general has been at fault for the igflation" economy of the 1960's and 1970's. Unemployment and ation were on a roller coaster, rising to higher peaks and ighs, seriously affecting longrun productivity and economic wth performance. While Keynesianism may have served us well he 1930's and 1940's, and perhaps in the 1950's, it did not serve well in the 1960's and 1970's. Policy actions were alternatively on "stop" or "go" in an attempt to fine tune the economy and economy responded in kind like a stagflation roller coaster n the mid-1960's until 1980. The distortions and economic mal- of this stagflation period had very negative effect on longrun luctivity and real GNP growth.
econd, the United States is very much a consumption-oriented ety, far more prone to consume than to save resources. It takes ifices to invest in economic growth, and this is a fundamental ciency in the U.S. economy. Table IV shows that the United tes has systematically invested a relatively smaller proportion ts resources into growth-producing capital formation than have er industrial nations. Our investment as a proportion of gross estic product has been consistently smaller than our industrial petitors, particularly Japan. As a consequence, the United

States has experienced slower productivity growth and GNP growth and, thus a decline in the U.S. share of total world output.

TABLE IV.—GROSS FIXED CAPITAL FORMATION AND SAVINGS AS A PERCENTAGE OF GROSS DOMESTIC PRODUCT FOR SELECTED YEARS

	1962	1970	1978	1982
Gross investment as a percentage of gross domestic product:				
United States	17.6	17.6	19.5	16.6
Canada	20.5	20.8	22.2	21.1
Japan	32.9	35.5	30.8	29.6
France	21.4	23.4	21.4	20.5
West Germany	25.7	25.5	20.8	20.5
Italy	23.7	21.4	18.7	19.0
United Kingdom	16.8	18.5	18.0	15.4
Average, excluding United States	23.5	24.2	22.0	21.0
Gross savings as a percent of gross domestic product:				
United States	18.9	18.1	20.3	15.9
Canada	20.8	21.2	20.1	19.0
Japan	34.8	40.2	32.3	31.6
France	24.6	26.2	22.6	18.5
West Germany	27.3	28.1	22.8	21.5
Italy	26.0	24.2	22.4	18.8
United Kingdom	16.9	21.5	19.4	16.9
Average, excluding United States	25.1	26.9	23.3	21.1

Source: OECD Economic Outlook.

Investment in up-to-date plant and equipment is crucial to productivity growth. Capital formation and labor productivity fit together like hand and glove. In the 1950's and 1960's, the U.S. capital-labor ratio grew about 1¼ percent a year, actually declining in 1980. The slow growth of the capital-labor ratio in the 1970's is at the root of these reduced rates of productivity during the decade.

SAVING

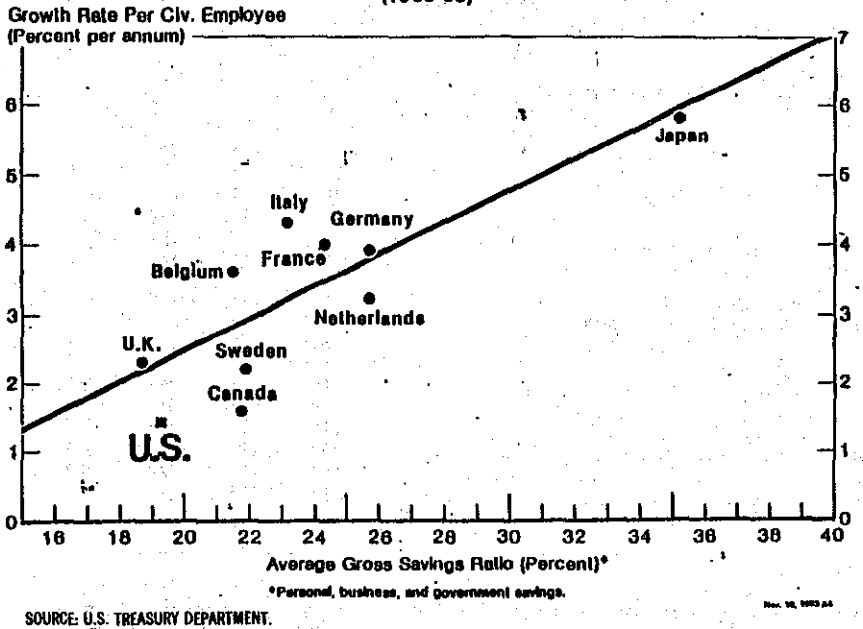
The financial capital for new investment spending comes from saving. Unfortunately, in our consumption-oriented society, the saving rate has declined. The average ratio of personal savings to personal disposable income in the United States fell from 7.3 percent in the 1970's to 5 percent in 1983. It has been running at about 6 percent in 1984, and appears to be on an uptrend. On the other hand, the Japanese save about 19 percent of their personal disposable income, and the West Germans save about 14 percent.

The trend in *gross* saving—including individuals, businesses, and government—is shown in the bottom tier of Table IV above and also in Chart 2 below. Clearly, the United States trails other industrial nations, in some cases, by a long way. A look at history and what our industrial competitor countries are doing should convince us once and for all that the countries that have the highest saving rates also have the highest investment rates and, accordingly, the highest productivity rates, the major factor in economic growth.

CHART 2

U.S. HAS HAD ONE OF THE LOWEST RATES OF SAVINGS AND PRODUCTIVITY GROWTH

(1960-80)



*Personal, business, and government savings.

SOURCE: U.S. TREASURY DEPARTMENT.

"Attitude" is not the only problem contributing to the U.S. consumption, low-saving pattern. Federal policies, particularl policies, have not been growth oriented. The U.S. low-saving set is *greatly influenced* by a Tax Code that imposes doubl ation on savings—first on income, then on the income res from the investment of that income. In the corporate sector, ings are taxed first as profits and later as dividends. Inflation pounds the problem by forcing individuals into higher tax bra and by inflating corporate profits and distorting depreciation ances. The net effect of the tax system is to lower the r return on saving and investment.[3] And it is not just the impact on income and profits that hurt. Inflation also wrecks with investment by introducing serious uncertainties into t vestment process.

Third, government regulatory policies have also contribut our low productivity growth by diverting resources from prod purposes to meeting environmental, product safety, and occu health standards.

Government regulation, although desirable and benefici many cases, imposes heavy costs on society. The heavy cost burdens on business (and ultimately on the consumer) have almost ignored in setting regulatory policy. Regulation appe have been pursued with "tunnel vision," looking only at the fits, without concern for costs. It is time we took a hard look a cost side of the equation; both the dollar costs and the tim burden costs. The Carter Administration started this proces the Reagan Administration has picked up the pace. This is n say benefit consideration will be set aside, only that costs w considered along with benefits.

We must improve cost-benefit analysis and monitor techniqu the regulatory agencies. Contradictory, duplicative, and unsu ful regulations must be eliminated. This is the course that will to increase productivity and foster economic growth, and achieve the desirable aims of regulation.

Improvements in the Productivity Environment

Fortunately, many of the factors that had a negative impa productivity growth in the 1960's and 1970's have been rever With regard to the first factor on the above list, except for real interest rates, the U.S. macroeconomic scene is in good c tion right now. Inflation is low; growth is high; employment i panding and, while there has been some slowdown in growt cently to more sustainable levels, the solid noninflationary ex sion of the last 2 years should continue for some time to come. provides a sound base for further productivity gains. Most im tant, tax policy has been set on a growth course, instead of a

[3] For a detailed description of how inflation, interacting with the Tax Code, has disco long-term U.S. capital formation and economic growth, see U.S. Congress, Joint Economic mittee, "The 1981 Midyear Report: Productivity," Report of the Joint Economic Comm Washington, D.C., Government Printing Office, 1981, pp. 1-25. Also see U.S. Congress, Join nomic Committee, "Productivity and Inflation," study prepared for the Joint Economic Co tee, Washington, D.C., Government Printing Office, 1980.

[4] See an opinion editorial on this point by Professor John W. Kendrick, Wall Street Jo Aug. 29, 1984.

. There is more to be done on this. We could take some les-
rom the Japanese.
h certain limitations, the Japanese do not tax saving income.
he other hand, the United States generally double taxes
—when income is earned initially and, again, on the earn-
rom investment of that income. The Japanese have several
tax provisions that directly encourage investment: (1) with
tions, there is no capital gains tax on individuals; (2) the tax
n investment income is 35 percent, half the regular top 70
nt marginal rate; (3) Japan has an R&D tax credit; and (4)
is a 10 percent tax credit for individuals receiving corporate
nds, thus reducing some of the burden of double taxation. Of
e, these measures, by raising the after tax rate of return on
tment, provide an additional stimulus to saving, since the op-
nity cost of current consumption rises.
the whole, the United States has taken some enlightened
in the last 4 years to improve the tax environment for
ctivity and growth, but more can be done and we trust will be
It may be time for the United States to move to a flat-rate
mption tax. This tax system would have the ultimate benefi-
ffect on savings and investment.
costs of complying with social regulations have begun to
out as a percentage of GNP after major increases in the
. Moreover, some of the uncertainties, so destructive of incen-
to invest, are being removed by regulatory reform. Economic
ulation is lowering prices in some portions of the transporta-
communications, and financial sectors and has increased com-
ve incentives for higher productivity. The work on this, begun
esident Carter, has been continued under President Reagan.
post-World War II baby boomers who swelled the ranks of
erienced youthful workers in the late 1960's and in the 1970's
ow passing into their productive working years, with benefi-
ffects on productivity.
ally, there have been favorable developments in labor-man-
ent relations in the past several years as a result of the
t of keen foreign competition and the recessions of 1980 and
82. Not only have nominal wage-rate increases moderated sig-
ntly, but many new union contracts have reduced or eliminat-
strictive work rules that hurt productivity. Both union and
nion workers increasingly are participating in quality circles
ther joint labor-management team efforts to improve produc-
. There has been a substantial turnaround in productivity and
mic growth in the United States since the recession ended in
mber 1982. We are optimistic that this can continue for many
to come—if we pursue intelligent policies.

Technological Innovation

major determinant as to whether the U.S. economy will,
d, enjoy a healthy longrun secular rise in productivity and
mic growth hinges very much on item No. 3 in the above list
ctors that affect productivity (i.e., technological innovation).
is the subject of the remainder of this chapter and the remain-
f this study.

Technological advancement is probably the least understooc all the factors affecting productivity and growth. And yet, it is of the most important contributors to growth. In fact, it is proba the chief long-term factor driving up productivity, based largely research and development. Technological advancement is defi as technical and managerial knowledge that leads to new and proved production methods and processes, and to new products services. It also includes more efficient utilization of resources a result of improvements in organization, management techniq transportation, and communications.

Quantity increases in capital stock (item 2 on the foregoing are a necessary but not a sufficient condition for good producti growth. There must also be improvements in the *quality* of capi via technological advancement (item 3 on the foregoing list). In vation is also a necessary but not a sufficient condition for pro tivity growth. Increases in the quality of the capital stock alone not enough. *Both* are necessary.

Much has been written about capital investment and its cor bution to productivity.[5] There is considerably less literature on role of innovation.

What produces technological innovation? The following are s of the basics:

1. Expanded research by government and research and deve ment by the private sector is the most important factor.
2. Increased supply of scientists and engineers.
3. Good patent and antitrust laws.

Technological innovation is basically a private sector activ but there are some things the Government can do. Some poli are highlighted here.

The most important factor in technological innovation is an gressive research and development program by both the priv and public sectors.

The United States has been the world's technological lea throughout the postwar period. U.S.-based scientists have wo major share of Nobel prizes. Indeed, the U.S. economy originate large proportion of all new products. Only Japan is a serious cl lenger to our technological leadership.

Yet, as our trade deficit with Japan in high technology increa serious questions are being raised about our ability to retain technological position. For example, 10 years ago America's lead ship position in microelectronics was unchallenged. Now in seve critical areas, the Japanese are verging on leadership. Unless c rent trends are reversed, the advantages the United States n hold will erode further. It is essential that we assess and bols the critical wellheads of technological advancement.

Research and Development

If investment in physical capital is the vehicle, research and velopment is the engine of technological progress and productivi R&D improves the *quality* of capital of state-of-the-art advan ments. A recent study by the National Bureau of Economic

[5] See bibliography at the end of this study.

rch shows a positive connection between the rate of R&D expenditures and the rate of productivity increase in various industries.[6] Edwin Mansfield has shown that productivity growth in an ustry or in a firm is directly and significantly related to the ount spent on R&D by that industry or company.[7] In another dy, Richard T. Atkinson found that growing industries—those erating new jobs and rising income—have relatively high rates nvestment in R&D.[8]

here are important "spillover" effects from R&D because one ustry's R&D frequently results in important inputs in other intries. In a study of 17 innovations in various industries, Mansd found that the median *social* rate of return on investment is e than double the median rate of the return to the company lf, before taxes.[9]

he United States and West Germany have the highest ratios of arch and development to gross national product of any indusl country. From the late 1960's to the 1970's, the share of R&D enditures to GNP in the United States fell from about 2.9 per in 1967 to about 2.2 percent in 1978. It has risen since then to percent in 1984. The U.S. ratio exceeded Germany from the late 's to the mid-1970's, but has followed behind since then. Overthough, the U.S. spending on R&D relative to GNP has grown apidly as any other industrial country since the late 1970's.[10] Chart 3.)

hen military research is stripped out, the United States falls 1 into the pack. Chart 4 shows civilian research and develop t expenditures as a percent of GNP in four major countries. In , the United States led the other industrial countries but has trailed Germany and Japan by wide margins, although the ratio has been on an uptrend since 1978.

1981, the latest year for which data are available for all indus countries, civilian R&D expenditures in Germany were 2.6 nt of GNP. In Japan, the ratio was 2.3 percent. In the United s, it was 1.7 percent. While there is a great deal of spillover fit to the civilian sector from military R&D expenditures, it is lear that the United States needs to commit a larger share of to civilian research and development if we hope to maintain echnological lead in the world.

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ional Bureau of Economic Research, "R&D, Patents and Productivity," University of Chiess, Chicago, IL, 1984.

in Mansfield, Seminar on Research Productivity and the National Economy, House tee on Science and Technology, June 18, 1980, p. 6. Also: "How Economists See R&D," l Business Review, November-December 1981, p. 98.

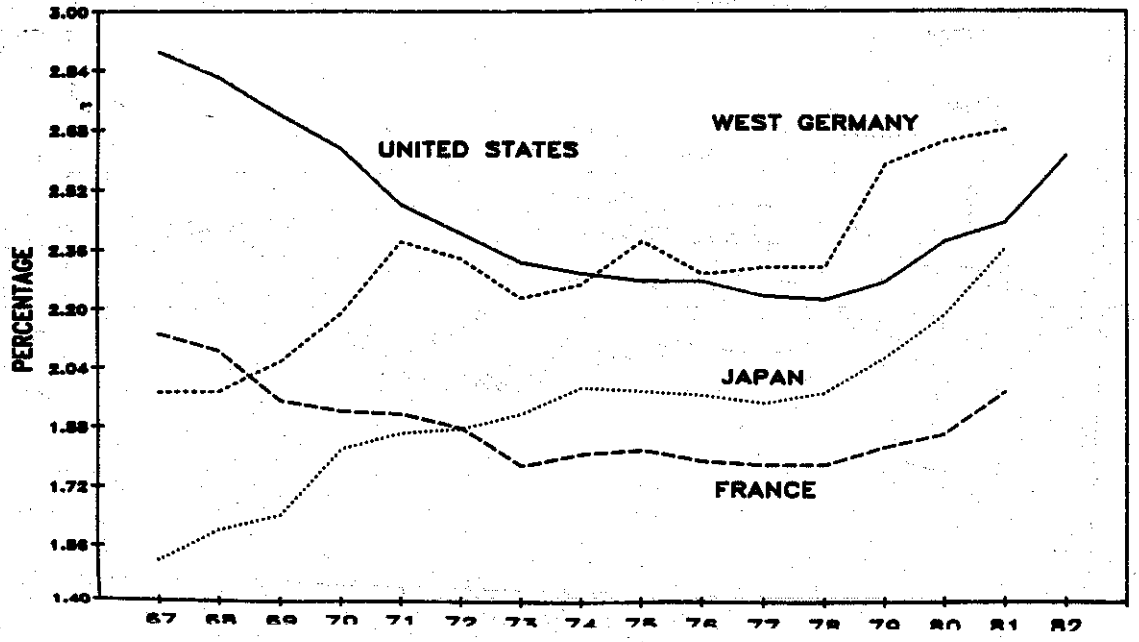
ard C. Atkinson, "The Role of Research and Development in Economic Progress," Nacience and Technology Policy Issues, House Committee on Science and Technology, 1979,

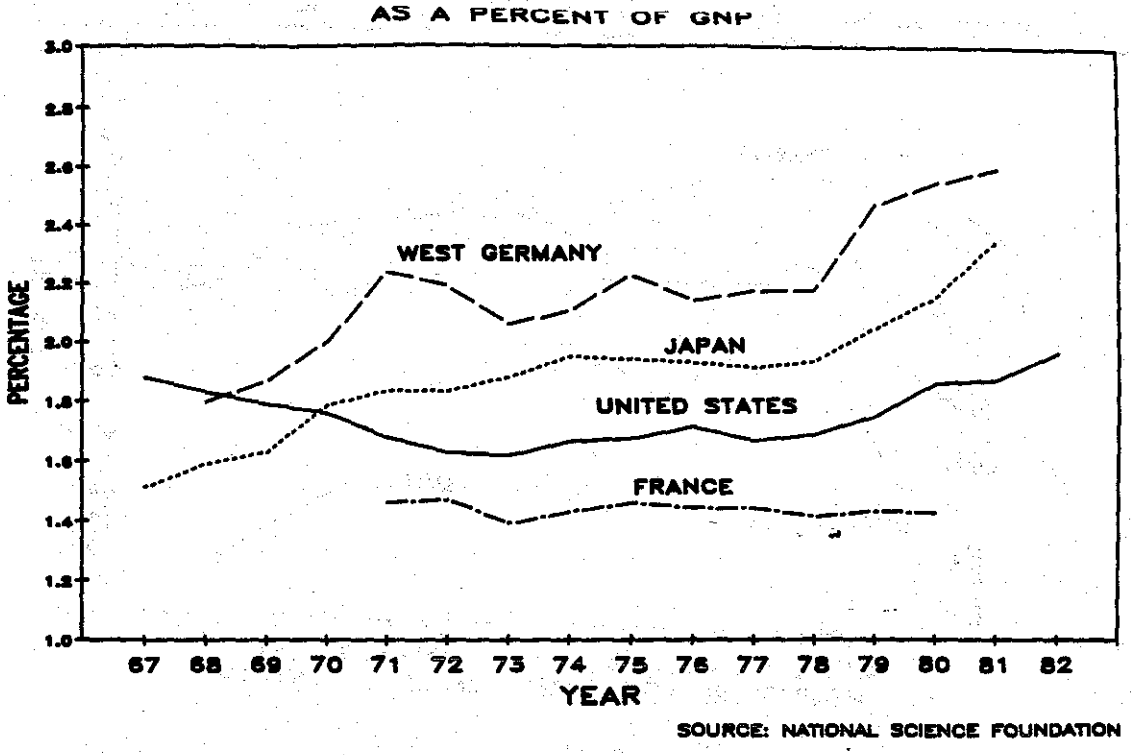
in Mansfield, "Economic Growth and Stagnation: The Role of Technology," National g Association, "Looking Ahead and Project Highlights," spring, 1980, p. 5.

e: Data on R&D in the United Kingdom are very sketchy, generally unavailable, and shown on Charts 3, 4, and 5.

CHART 3

NATIONAL EXPENDITURES FOR RESEARCH AND DEVELOPMENT AS A PERCENT OF GNP





SOURCE: NATIONAL SCIENCE FOUNDATION

In fiscal year 1984, the United States spent $97 billion on R&
of this, $44 billion, or 46 percent, was funded by the Federal G
ernment. This is an historic low figure for the Federal share
R&D spending. However, the Federal Government still play
major role in basic research.

Basic research accounts for 12 percent of total research expe
tures and applied research for 22 percent. Development activi
comprise 66 percent of the national R&D outlay. The Federal G
ernment funds two-third of the Nations basic research, and ri
fully so. This is the type of research where the benefits are uncl
and privately funded researchers often cannot undertake the r
Yet, it is the area where knowledge and understanding of the f
damental aspects of the universe are gained, and such resea
serves as the foundation of many innovative products and proc
es.

Fortunately, one previous thorn in the side of R&D was clea
up late in the 98th Congress. Some uncertain legal restraints
joint R&D ventures were corrected by Public Law 98-462, and j
ventures can now go forward without fear of bringing down
wrath of the Antitrust Division. This will avoid costly duplicat
in R&D.

More can and should be done to promote commercial R&D.
one thing, the 25 percent tax credit should be made permanent
is scheduled to expire next December. We should also: (a) repl
the rolling base restriction with a base using an average of 1983
R&D expenditures; and (b) permit tax deductions for contributi
of equipment for teaching science. (Under present law, equipm
can now be donated for research purposes.)

The increase we have had in R&D spending the past few ye
even after allowance for lags, is contributing, and will contrib
to an increase in the flow of cost-reducing investments and inno
tions. We urge that the increases in R&D spending the past
years be extended, particularly by the Federal sector, but also
the private sector.

Supply of Scientists and Engineers

Money alone will not achieve research and development. It
quires an expanding scientific and engineering manpower ba
The number of R&D scientists and engineers in the United Sta
rises year by year—from 530,000 in 1967 to an estimated 750,
today. Both in total and relative to the total labor force, the Uni
States has the highest proportion of scientists and engineers in
labor force of any country except the Soviet Union. However, fr
the late 1960's through the early 1970's, the ratio of R&D scienti
and engineers to the labor force declined in the United States, fr
67.2 per 10,000 in 1967 to 55.8 in 1976. The ratio has increased
the past few years, rising to 64.6 in 1982, but it has not yet
gained its former level. In most other countries, especially Jap
and West Germany, this ratio has steadily increased over
1960's and 1970's. (See Chart 5.)

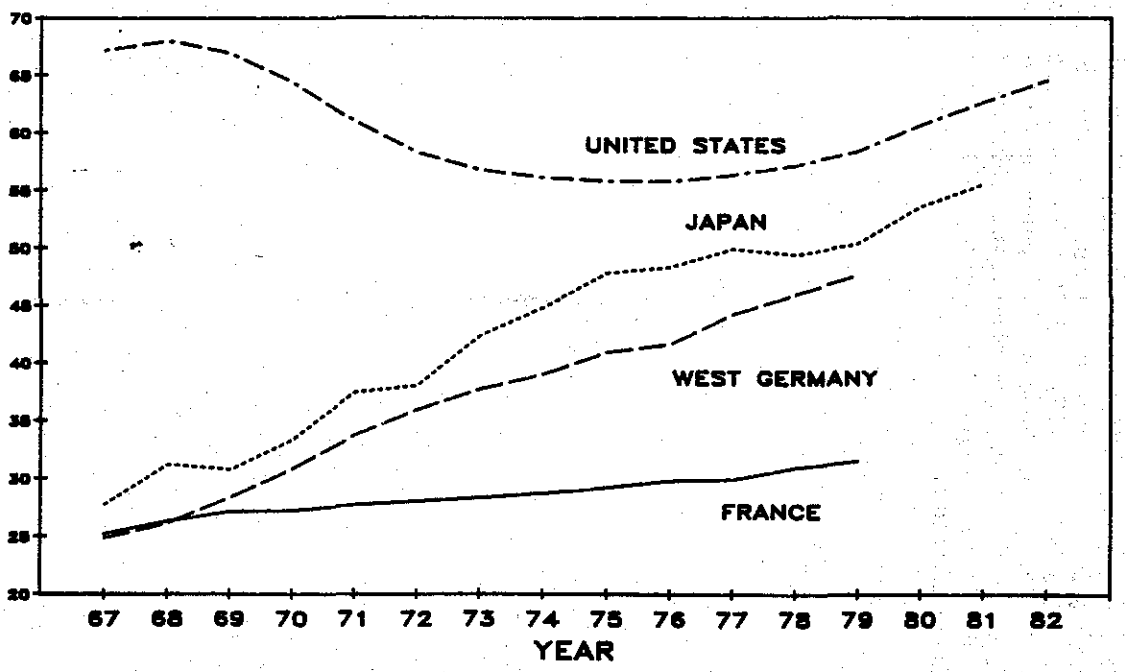
Moreover, some of the best U.S. scientific and engineering m
power has been diverted to the defense and space programs, at
expense of civilian programs. We will have to face up to the f

it national defense requirements will always absorb a major por-
n of U.S. scientific and technological manpower, and the recent
ansion in weapons procurement has added and will continue to
l additional demands on the Nation's scientific and technological
ources.

But of major concern relative to the growth in the labor force is
t the supply of scientists and engineers in the United States has
en markedly behind the growth ratios of other advanced indus-
l nations. In 1980, the United States granted 69,300 bachelor
ree-level engineers, while Japan graduated 73,500, with a popu-
on half that of the United States. The effect has been to drive
wages for engineering talent, thereby increasing the costs of
D, and constraining its scope. The United States needs a re-or-
ing of educational priorities if we are to continue to be the
ld's technological leader.

CHART 5

SCIENTISTS AND ENGINEERS ENGAGED IN RESEARCH AND DEVELOPEMENT PER 10,000 LABOR FORCE POPULATION

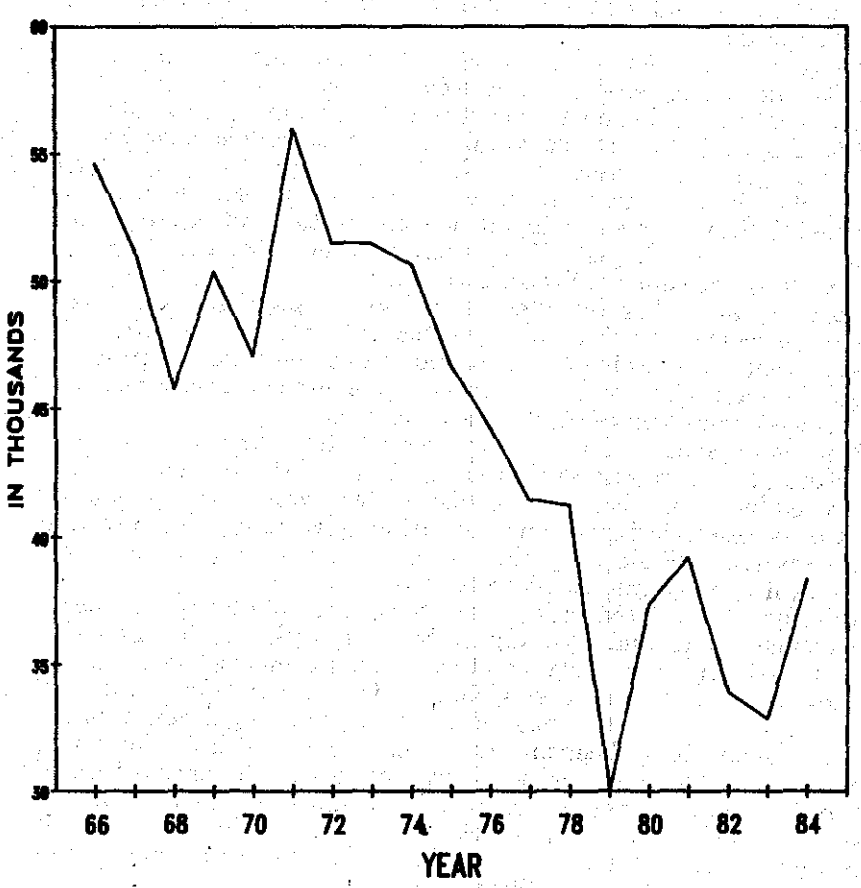


SOURCE: NATIONAL SCIENCE FOUNDATION

Of course, manpower and dollar inputs into the R&D process can only proxy for what we are seeking—innovation. Innovation is difficult to measure, but a good indication of what is occurring is patent statistics. The trend on domestic patenting is clearly down. The decline between 1971 and 1984 is over 31 percent. This is shown in Chart 6. At the same time, patenting in the United States by Japan and Germany has been rising and, in 1982, over 40 percent of all U.S. patents granted went to foreigners, primarily to Japanese inventors.

CHART 6

U.S. PATENTS GRANTED TO U.S. INVENTORS
1966 - 1984



SOURCE: U.S. DEPARTMENT OF COMMERCE, U.S. PATENT AND TRADEMARK OFFICE

Some of the problem lies with the U.S. patent system itself. The patent system was created to promote innovation, but certain aspects of the system are barriers to innovation. One problem is that title to inventions made under Federal funding generally is vested in the Government (with the exception of those inventions made by small businesses, universities, or not-for-profit organizations). Only 5 percent of government-owned patents are ever utilized in the private sector, compared to 40 to 65 percent of private-owned patents.[11] The reason is that without title to an invention and 17 years exclusivity it provides, an individual or company will not invest the time and money necessary for the development of a marketable product.

There is some controversy on this. Some proponents argue that title should remain in the public sector where it is accessable to all interested parties. Permitting contractors to retain title would constitute a subsidy to large companies and would reduce competition. Large corporations, which have the ability to procure government contracts, would benefit the most. Nonetheless, responsibility for commercialization resides in the private sector and, then government retains title, industry is less likely to follow up with the additional steps necessary to produce an innovation.

Congress has taken one step to correct the problem. Public Law 96-517 provides for title to be vested in contractors if they are small businesses, universities, or nonprofit institutions, provided they commercialize within a brief, agreed-upon, timeframe. The law should be expanded to cover all contractors.

One other aspect of the patent process that needs attention is that the 17-year patent life should begin after the patent is finally approved by the Government. Under current procedures, patent approval is excruciatingly long, awaiting government testing and legal research. While a "patent pending" stamp may be some deterrent, it is no guarantee of protection.

Finally, in a related matter, antitrust and intellectual property laws should be amended to require the courts to consider the effect of competition when judging alleged patent misuse by a patent holder and alleged antitrust violations in the licensing of intellectual property. Often, the most efficient way to bring a new technology to market is by licensing that technology to others. Licensing can enable intellectual property owners to use the capabilities of established enterprises to market a technology quickly and at lower costs. This would be especially valuable in the case of small businesses that do not have the ability to develop all possible applications of new technologies by themselves.

On another matter, patent protection by U.S. process patent holders should be strengthened by enforcement of a U.S. patent against a product made in a foreign country by the U.S. patented process. Today, foreign companies can use U.S. process patents abroad without authorization, and turn around and sell the resulting products in the United States with impunity.

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[11] Wendy H. Schacht, "Industrial Innovation: The Debate Over Government Policy," Congressional Research Service, Library of Congress, published issued brief, Aug. 22, 1984.

III. UNIVERSITY-INDUSTRY COLLABORATION

The growing importance of basic research to American indus has strengthened backward linkages to the American unive system. Universities and industry are developing a wide varie collaborative mechanisms to benefit both parties. The result is emergence of the role of academe in the Nation's overall env ment for entrepreneurship and innovation.

This chapter examines factors behind the growth in the univ ty-industry collaborations, the benefits to both parties, and the falls to be avoided in such relationships. The chapter concl that university-industry collaborations, properly structured to tect the academic integrity of the American university sys offers an attractive means to speed the development and diffu of commercial technologies.

The first section of this chapter examines the emerging ro academe in economic growth in the light of America's entre neurial revolution, and the profound changes that have affe university-industry linkages in recent years. The second sec looks at the economic potential that exists in stronger univer industry collaborations, with special attention to the implicat of such collaboration for entrepreneurship and innovation. danger of carrying the collaboration to the extent that it viol the fundamental principles guiding the university is also discus The third section describes the practical difficulties that l arisen in setting up collaborative efforts, and the efforts mad overcome them. These difficulties stem from industrial and gov ment policies and attitudes as well as university ones. The answ however, stem from both groups who have made efforts to un stand the singular roles that universities and commercial fi play in our capitalist society. The chapter concludes with a dis sion of how Federal policies can help maximize the benefits of versity-industry collaboration.

The Emerging Role of Academe

For centuries, universities have provided the world with kn edge and educated manpower, while pursuing the fundamer principles of intellectual freedom and scholarly communication. though they have not shied away from controversy, the more du ble of them have maintained their essential qualities through v and sometimes sudden changes in the political and economic str tures of the nations where they have been situated. Today, as t were centuries ago, universities are still the world's primary sou of basic knowledge and free inquiry.

They are also one of the most stable institutions of mankind. the 66 institutions today that have kept their original form fr the early 16th century, 62 of them are universities. This stabi

idently stems from the value society places on institutions that adfastly follow these principles of inquiry and communication. it it is also the result of a deliberate pragmatism. As a witness fore the Joint Economic Committee pointed out, "Our universi- s *do* change in response to societal influences, while seeking to eserve their fundamental characteristics." [1]

Universities in the United States are again under challenge to ange, in ways that possibly threaten their independence. This allenge comes from a familiar combination of economic and polit- il pressures, including pressures from government.

The present setting, however, is unique. It is influenced by two aracteristics of our technological age that have altered, perhaps rmanently, the interaction between university and commercial search.

1) There is a growing dependence of the Nation's economic and siness system on technological information which, in its basic m is usually found at university; and

2) In several areas there has been a substantial increase in the ed at which basic research findings are being translated into hnology with commercial potential. In this "postindustrial" era, *formation* is the key to economic competitiveness as much as ma- ial strength and ingenuity were previously. As the source of sic information, the university is now looked to by many technol- y-intensive firms as possibly providing the answers to matters of me business importance. As one high-tech executive described it ently:

> Inventions of ultimate technological and economic significance once could be made by intelligent, persistent thinkers with little formal higher education. Edison, the Wright brothers, and Henry Ford come to mind. Modern technological advance, however, is a different story. Consider the transistor, the laser, or synthetic insulin. . . . You don't find these associated with tinkering in a basement or garage. . . . Thus, the modern R&D enterprise is inextricably linked with the research university. . . .[2]

Government is concerned with these "inventions of ultimate hnological and economic significance," both as a consumer of h technology and as a prime mover of economic growth. The nd of government in promoting a closer linkage between indus- and universities can thus be seen at all levels, Federal, State, l local. Bills to establish generic technology centers at universi- s, to subsidize research parks associated with universities, and to bsidize university research in specified technologies have been in- duced in the 98th Congress. State governments, through their te university systems, are active in promoting their economics centers of technological development. Many local governments ve helped establish business development and "incubator" facili- s, often combining with local universities to do so.

Donald N. Langenberg, testimony published in U.S. Congress, Joint Economic Committee ings on "Climate for Entrepreneurship and Innovation in the United States," parts 1, 2, and 3, ess., 98th Cong., p. 13.

Ibid., p. 8.

The swiftness of the pace of technology development is also a matter of government concern. Speaking of the revolution in science that has been taking place around us, one observer noted that "the relatively long time lag [between basic research findings and commercial development] has practically vanished in many fields of scientific and industrial activities."[3] This has resulted in a broader overlap between the basic research being carried out at universities and in industrial firms. In more and more fields—for example, surface analysis, molecular beam epitaxy, and laser-assisted DNA analysis—the academic researcher is dealing with the same scientific and engineering problems as the industrial one.

Thus, the industry-university connection is germane to a report on the Nation's climate for entrepreneurship and innovation. The modern, high-tech entrepreneur sometimes comes from a university staff. More often, as this chapter points out below, he or she benefits from some university affiliation. In many cases, the entrepreneur has developed technology that is purchased by larger firms, who themselves carry on an extensive university-collaborative network. In any event, each party relies on—and is often involved in developing—the basic knowledge and research that is generally found in a university setting.

The Potential of University-Industry Collaboration

Gatorade, stannous flouride as a toothpaste ingredient, irridated milk, lasers, anticoagulants, synthetic fibers, semiconductors, and atomic power: These products owe their existence in whole or in part to university research. If the list were extended to include all inventions in use today that derived from such research, it would extend to hundreds of entries.

This albeit simplistic view of university activity—that it provides the basic, and some of the developmental, research undelying important commercial developments—has been accepted by policymakers and industrial leaders, and built into the legislation that established and still guides the university-industry-government system this country enjoys today. With the passage of the Morrill Act more than 100 years ago, Congress established a tripartite partnership that has helped produced some of the most technologically modern industries in the world. The land grant college system has set the standard, as it were, for many other institutions in their dealings with industry.

Today, the Federal Government provides approximately $5 billion for university research, or about two-thirds of university R&D funding. While industry contributes less than $½ billion for university R&D, it provides significant other funding for facilities, scholarships, etc. Industrial contributions to universities have continued to grow during the postwar era, and presently amount to more than $1.2 billion per year.

A number of important public policies have been encouraging and facilitating the trend to improved university-industry relations. The provisions of the Economic Recovery Act of 1981 provides tax

[3] George E. Palade, in Thomas W. Langfitt, et al., eds. "Partners in the Research Enterprise: University-Corporate Relations in Science and Technology," Philadelphia: University of Pennsylvania Press. 1983.

incentives to encourage university-industry collaboration. The incremental R&D tax credit allows a 25 percent credit for 65 percent of the cost of contract research, including payments to universities and faculty. Also, deductions for equipment and donations to universities increases the attractiveness of industry collaboration with universities.

Probably the most significant statutory incentive has been changes in patent laws, to allow universities, small businesses, and nonprofit organizations to have title to patents developed from federally funded research. The potential for fees from leasing and licensing development rights to university patents provides a powerful incentive for universities to seek out research ties with industry, and to compete more vigorously for Federal R&D funding as a mechanism for leveraging corporate R&D support. Many major universities now have patent offices and faculty consulting and research policies to facilitate collaboration. The development of research parks at or near major university facilities is also being used to lure industry.

Over the past few years, dozens of experiments have been mounted to make this connection more productive. The Federal Government has sponsored several industry-university joint programs in addition to its own research contracts with universities. Virtually every State now has a "high-tech" initiative as part of its economic development activities. Some industrial firms have made conspicuously large or innovative arrangements with universities to promote advances in technological fields such as chemical research or manufacturing technology. In the field of biotechnology, approximately 200 "startup" firms have been established recently, many of them by university researchers; this has happened, to a lesser degree, in other fields such as computer science. And many universities seem to be more open than previously about engaging in industry-oriented research and other assistance.

These developments have brought their problems for both parties, but especially for universities. In 1982, for example, a "summit" conference of university presidents sounded the warning that research arrangements with industry should—

> not promote a secrecy that will harm the progress of science; impair the educational experience of students and postdoctoral fellows; diminish the role of the university as a credible and impartial resource; interfere with the choice by faculty members of the scientific questions they pursue, or divert the energies of faculty members and the resources of the university from primary educational research missions.[4]

What kinds of conclusions can we draw from these activities about the future of American entrepreneurship? This study identifies six primary ones, each of which affects the response that the Federal Government might take in improving the Nation's environment for entrepreneurial activity.

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[4] Report of the Pajaro Dunes Conference (excerpt reprinted in Partners in the Research Enterprise), op. cit., p. 36.

Common Interest

First, there is a natural convergence of interest that has bec more prominent recently between technology-based firms and versities.

From an industrial standpoint, a technological advantag sometimes critically important for maintaining competitiven Universities, in this context, are an important base for indust technological resources. Basic research has always been an im tant—usually indirect—input to developmental research, especi at the design stage. Today, however, in some fields it is difficul distinguish the two from each other. At least one university p dent has observed that "the lines between basic knowledge an application are becoming blurred in a number of fields; and fundamental research often provides solutions to industry's p lems."[5] Apparently, as the gap between basic and developmen search narrows—as it evidently has for many industries—cl university-industry ties become more beneficial to both parties.

Access to universities can accelerate this development pro Often the access to university basic research can best be ga through hiring someone who has worked on the relevant techn gy as a graduate student or professor. Therefore, an important ditional benefit that industry derives from a close connection universities is access to educated scientific and engineering n power.

From the university standpoint, the interest in closer ties industry is based both on the potential in closer ties and on the onomics of education and research today. The potential in cl ties stems from the fact that research departments of large co rations are often better equipped than the average university l ratory and often perform basic research that would be valuabl a university setting. Also, the scholarly communication that c acterizes university activity does not stop at the university ga The interchange of ideas also takes place through symposia, pro sional societies, and research organizations such as the Natio Research Council, which bring university and industrial scient and engineers together on a regular basis.

The economic basis for universities to seek closer industrial is practical as well. Faced with declining enrollments and ris costs, many universities have been forced to seek additio amounts of corporate funding. This has given impetus to special forts on the part of universities to establish industry-oriented ters for research in industrial areas such as biotechnology or m ufacturing (rather than traditional university scientific/engin ing areas such as biology or mechanical engineering). And unive ty scientists, a government-sponsored report notes, "are beginn to look to some industrial laboratories as a way to gain acces frontier equipment and technical advances." [6]

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[5] George M. Low, "The Organization of Industrial Relationships in Universities," Partne the Research Enterprise, op. cit., p. 68.

[6] Lois Peters, Herbert Fusfeld, et al., "Current U.S. University-Industry Research Co tions," University-Industry Research Relationships, National Science Board, 1982, p. 68.

The Public Interest

re is a distinct and somewhat different public interest in industry-university ties that includes government as well as ·sity and industry partners. A strong, productive industrial today is, by definition, one that keeps up to date in the ap- ion of the most advanced technology. The rapid rate of devel- it and application of new technology, therefore, has a direct g on this country's balance of payments, the inflation rate, e productivity growth rate. Maintaining America's ability to ate continually in the industrial sector will require maintain- vigorous and well staffed/equipped university system, and an ve set of mechanisms for technology transfer. There is con- ble evidence today that public policy officials are aware of tential of industry ties to strengthen the Nation's university 1.

Traditional University/Industry Roles Are Changing

nall shift in the traditional roles of industry and university idently taking place on some campuses and in many industri- ns. A number of university-based technology centers derive success from the quasi-entrepreneurial activities of their di- ; and staffs; these centers actively seek industrial contracts, illingly undertake some projects (e.g., product testing) that a itional university science or engineering department might nacceptable. On the other hand, some industrial firms per- asic and applied research with resources that are beyond the lity of most universities. Funded in part by large govern- ontracts, firms have made profound advances in the state of ; in such fields as numerically controlled machine tools, com- forming, and computer-aided design. A few large firms have e continuing education centers where many technological s are taught that are not freely available at most universities lesign for productibility, stress screening). In those fields industry has made great strides, technology transfer, rather om university to industry, is the other way around, from in- to university.

Research Setting Generates Entrepreneurial Ideas

kinds of entrepreneurs that have capitalized on high-tech in- 1 have typically depended for their ideas on a university or ustrial research department setting. In many cases, research ying a new invention has been started at a university or in- l firm; the spinoff of a new firm has occurred when the university or industrial firm became an inappropriate place ue the research further. In any event, proximity to a univer- group of universities, and to other high-tech firms, gives the ch entrepreneur the intellectual stimulus that would be un- le to smaller companies operating alone.

Universities Assist Startup Firms

lated factor, some startup firms that are too small to support esearch departments have found that they can avail them-

selves of university personnel and facilities—in effect, gaining advantages of a larger research department at a lower cost. ' advantage can be critical where expensive testing equipment is volved.

Universities Can Leverage Corporate Research Budgets

The array of Federal and State government programs to sup high-technology development at universities enables each indu dollar to be substantially leveraged when used to pay for univer research. Most government-sponsored, university-based rese centers cover their overhead with taxpayer funds; thus, indust "clients" pay only for materials and staff time. One such ce that receives support from the State legislature and the Nati Science Foundation, as well as industry memberships, estim that the leveraging factor for each industry dollar is approxima 200 to 1.

The above points indicate the potential for speeding the pro of the commercial development of new technology that ex through industry-university partnerships. They also indicate pitfalls being encountered, and the dangers in pushing indus university collaboration too far. For the fact is that too close identification of university interests with those of its indust sponsors could compromise the principles upon which the unive ty is based. This is not an idle issue. One of the Committee's nesses, himself a university chancellor, warned that "our resea universities are wrestling with many fundamental questions ab the extent to which they should or can strengthen their inter tions across the interface with industry and the private sector g erally, without risking damage to the fundamental academic val which are the basis of the stability and durability to which I ferred earlier." [7]

Indeed, the lure of economic growth through high-technology velopment has attracted significant governmental interest, Feder State, and local. Most of this is based on the simple but effecti notion that the "Silicon Valley" model has potential for oth parts of the country. Thus, most State university systems a deeply involved in promoting industrial relations, through "incul tor" facilities, engineering centers of excellence, specialized ind trial research consortia, and even aiding access to venture capit

Barriers to University-Industry Collaboration

In most cases, there has been insuficient experience to determi whether these recent government efforts to promote industry ti have been successful. A recent survey of industry-university-go ernment collaborations, for example, indicates that 105 out of 1 such collaborations have been founded in the past 5 years.[8] Ea year has seen an increasing number of such collaborations. The is little literature, however, on the consequences of such collabor tions, or their implications for university independence.

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[7] Langenberg, op. cit., p. 19.
[8] Helen D. Haller, "Examples of University-Industry-(Government) Collaborations," Itha Cornell University, Aug. 1, 1984.

What evidence there is suggests that, notwithstanding the bene-
; of such collaborations, there is no easy route to success. The
iversity connection is no complete substitute for a vigorous, in-
use research program or for entrepreneurial talent. On the other
nd, the industrial dollar is not simply money; it often comes with
tain stipulations that influence university research activity. The
lowing paragraphs describe some of the most important issues
ecting industry-university collaborations, from the industry, uni-
sity and governmental standpoints.

The primary difficulty stems from the traditional roles of indus-
and university. The former is oriented toward production and
rkets; much of the product and market information it employs
proprietary; many of the problems it must solve are multidisci-
nary; and its employees are rated on the basis of their "commit-
nt to deliverables." Universities, on the other hand, are oriented
ard instruction and the pursuit of knowledge; they are dedicat-
to the publication of research findings; their academic depart-
nts, and research activities, are organized by discipline; they are
isfied in their research goals to employ a "best effort," rather
n "commitment to deliverables" standard.

Most university personnel must divide their time between in-
uction and research. This means that industrial researchers who
employed full time find the pace of university research rather
w. A related problem, discussed below, is that few universities
afford the new generation of expensive equipment that could
ed research results.

Modern, advanced technology research is expensive. Further-
re, it is virtually impossible for any one university to afford the
chase and maintenance of equipment that will make it a center
scientific/engineering disciplines at once. One large university
cialized research center, for example, enjoys a $3 million State
mitment for the purchase of equipment only. Most of this
ipment is beyond the reach of other universities, but is in
mon use in large industrial firms. Newer generations of equip-
nt not only enable more rapid research turnaround; they are
more sensitive in their reading of data; permit greater accura-
where extremes (e.g., of temperature and pressure) are required;
automatically perform calculations that might otherwise have
e done by hand.

his poses a problem for universities, which must choose the sci-
ific and engineering areas where they will concentrate their re-
rces. It poses a corresponding problem for industrial firms,
ch must often establish ties with several universities in order to
benefits from university research related to the full range of
firms' activities. At the Government level, critical choices
ut grant allocation for industry-oriented research must be made
ed upon a sober assessment of each university's ability to con-
ute substantially to the body of knowledge in a particular field.
industrial research, key data are often utilized and even gen-
ted during the research phase of product development. If this
earch is performed at a university, the issue of proprietary in-
nation, and the publication of research results and data, come
he fore. Many cooperative research arrangements have disposed
his issue by allowing for university research results to be de-

layed, or by preventing students from having access to proprietary data. Nevertheless, there is considerable suspicion on the part of industrial firms as to both government and university publication of proprietary information.

Despite recent legislation permitting industrial research partnerships without violation of antitrust laws, the spectre of antitrust sanctions interferes with more productive industry-university relations. There are incidents where industry personnel attending a university meeting have asked the professional staff to sign documents attesting to the meeting agenda, the identity of other attendees, etc.

The research and development tax credit comes up for renewal in 1985. While it has tended to promote more research, and more industry-university joint research, there is little documentary proof of this. Some industrial research directors believe that failure to renew this tax credit could substantially impair this country's fine recent record in high-technology research, and nip certain industry-university consortia in the bud.

The demand for scientists and engineers is such that bachelor's degree holders often find it more lucrative to find work directly out of college, rather than pursuing further graduate study. Additionally, graduating science and engineering researchers can often be attracted to a firm because of the prospect of working on state-of-the-art equipment that few universities can afford. As a result, the number of U.S.-born graduate students in scientific and engineering disciplines has fallen substantially since the mid-1970's peak.

Conclusion: How Can We Maximize the Benefits?

The first three sections of this chapter describe the emerging role of academic research in an industrial setting and the opportunities/problems, respectively, of industry-university relations. The fact that there should be a strong partnership is a peculiarly American phenomenon, based in part upon the success of the land grant college system. Unlike the European system, where academic customs are given greater emphasis, both public and private universities in this country are often chartered in part to promote commerce matching barriers with incentives.

Until recently, the primary interest that business firms might have in establishing university ties was in being assured a reliable supply of skilled professional manpower. The first two sections of this chapter indicate, however, there is a potential for substantially more productive ties than the traditional one of the university as a recruiting ground for new graduates. The smaller, high-tech firm, which is one of the concerns of this report, has needs that go well beyond (and possibly do not include) recruitment.

Recent research has identified several characteristics or personalities that are present in firms that consistently develop commercially successful product innovations, especially innovations that are dependent upon advanced technology. These include:

1. The innovator, or idea person, whose creativity and research expertise regularly generate ideas that have commerical potential;

2. The manager/salesman, who "runs with the ball," often having to sell a new product or process to investors and executives who are uncomfortable with change;

3. The "technological gatekeeper," who keeps the company informed of technological advances elsewhere that are relevant to the firm's profitability;

4. The "market gatekeeper," who transmits customer needs and behavior back throughout the firm (related research indicates that a high percentage of product innovation in high-technology fields is customer-driven); and

5. The "manufacturing gatekeeper," who sees to it that new products are designed for manufacturability.

A small, newly formed firm must often combine two or more of these personalities in a single person. Government data indicate, for example, that one-half of all high-techology firms in this country have fewer than 20 employees. If a firm's major asset is simply a commercially exploitable idea, therefore, this still leaves it lacking in necessary skills and resources for making the firm prosper and continue to grow.

An increasing number of universities and State legislatures are coming to realize that a university is well situated to fill these gaps between a firm's existing resources and what it needs to compete in the marketplace. As the above analysis implies, however, this means paying critical attention to the traditional role of the university. Thus, there are at least 21 university-based centers that serve as "incubator" facilities and/or help firms obtain access to capital. At least 17 of these have been founded in the past 5 years.[9]

Chart 7 below sets forth the obstacles or problems associated with promoting better industry-university cooperation, described in this chapter and matches them with the incentives or interests that were described in chapter II. For example, the bottom line of the chart, "number of U.S.-born grad students in sci/eng is down," has implications for the national interest in maintaining a vigorous domestic scientific and engineering establishment; thus, an "X" connects it to the incentive/interest on the horizontal axis "Nat'l Interest in Sci/Eng."

[9] Information from Haller, op. cit., and field visits.