# The Growing Importance of Industrial R&D to the U.S. Economy

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# THE GROWING IMPORTANCE OF INDUSTRIAL R&D TO THE U.S. ECONOMY

## Executive Summary

U.S. industry is increasingly reliant on R&D to generate growth. Industry-funded research and development (R&D) as a percentage of U.S. GDP has risen 70 percent during the past 20 years.

High profits, heightened global competition, low interest rates, and other factors have fueled particularly strong industrial R&D spending in recent years.

Technological innovation has accounted for up to half of U.S. economic growth during the past five decades, according to the U.S. Office of Technology Policy. R&D is the primary source of technological innovation, and leads to creation of new and higher-quality products, and improvements to production efficiency.

Studies have found that industrial R&D spending produces average returns to investing businesses of about 25 percent. Returns of industrial R&D to the economy as a whole may be twice as high as this because knowledge generated by one company can Aspillover@ to other companies and create widespread efficiency gains.

Aside from its role in generating economic growth, industrial R&D produces new products that increase the quality of life, without necessarily being captured in economic output statistics. For example, R&D results in technologies that benefit the environment, increase transportation safety, and create life-saving pharmaceutical products.

The federal government can maximize industrial R&D by protecting intellectual property rights, minimizing taxation on savings and investment, and eliminating regulatory barriers to innovation and competition. For example, improving and extending permanently the R&D tax credit would lower the tax burden on research, and increase industry=s investment in innovation.

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## I. INTRODUCTION

Advances in knowledge have always been central to the economic growth process. Before the industrial revolution, advances in knowledge were generally left to small-scale artisans who improved production techniques with ad hoc experimentation. Scientific research was generally separated from the concerns of the business sector, and did not affect the standard of living for most people.

But scientific advances in a variety of fields changed this situation in the late 19th century. For the first time, businesses began to establish scientific research labs to create new and better products in a systematic fashion. Science and business came together for the first time. Today, discovery of better ways to make goods and services to improve our quality of life has become a very structured and specialized process of Aresearch and development (R&D).@

During the 20th century - and as we head into the 21st century - economic growth in industrial countries has become increasingly dependent on advances in scientific knowledge. In the United States, industry-funded R&D as a percentage of GDP has risen 70 percent during the past two decades. Today, Ainnovative efforts, and R&D in particular, are undoubtedly the major factor behind technical change and long-term economic performance,@ according to the Organization for Economic Cooperation and Development (OECD).[1]

The realization that R&D appears to play an increasingly important role in generating growth in modern economies has led governments in most industrial countries to provide various types of support for R&D. In the United States, federal support for R&D includes direct performance of R&D in government labs in fields such as medicine, financial support for university-based research, and the provision of incentives for private industrial research. Most funding for basic research B research that may not have an immediate economic payoff - comes from direct federal spending.[2] Most funding for market-oriented research comes from private industry.

To maximize private industry R&D expenditures, the federal government should pursue a variety of favorable policies. These include: patent protection to secure intellectual property rights, minimization of taxes on capital to encourage investment, and regulatory policies that don=t stifle innovation and change.

Additional support for industrial R&D comes in the form of the R&D tax credit. The credit is one of the most widely-supported incentives in the federal tax code. Since its introduction on a temporary basis in 1981, the credit has been renewed nine times. The R&D credit is currently due to expire at the end of June and there is bipartisan support in Congress to renew it this session.

In addition, a number of legislative proposals have been introduced to make the R&D credit permanent.[3] A permanent credit would allow research-intensive businesses to maximize usage of the credit and permit better long-term planning for industrial research programs.[4] Evidence suggests that companies have a significant lag time in adjusting their R&D spending plans, with the result that annual expiration and renewal of the credit means that companies don=t fully respond to the current incentive.[5]

Studies show that the federal budget may actually gain revenue over the long-term from a permanent R&D tax credit. A 1998 Coopers & Lybrand study found that permanent extension of the R&D credit would increase taxpayer incomes and tax payments enough over the long-term to more than offset the direct revenue loss to the federal budget.[6]

From a federal budget perspective, incentives for industrial R&D may produce more bang-for-the-buck than ever. This is because advanced technologies appear to be increasing the productivity of the R&D process itself. For example, U.S. industry is creating more innovations and receiving more patents per dollar of R&D spending than it used to.[7] Computer modeling and simulations, for example, have sped up the discovery process in many fields. In pharmaceutical research, computers have shortened drug screening times, and recent reports indicate that pharmaceutical firms are pressing hard to double the productivity of their research efforts within the next few years.[8]

In this study, Section II describes trends in U.S. expenditures on R&D, and identifies the most R&D-intensive industries. Section III discusses the importance of R&D as a source of U.S. economic growth, and outlines the processes through which R&D impacts the economy. Study conclusions are presented in Section IV.

## II. R&D TRENDS

### A. Growth in U.S. Industrial R&D Expenditures

Industry-funded research and development is playing an increasingly important role in the U.S. economy. Data from the National Science Foundation (NSF) shows that industry-funded R&D as a percentage of U.S. GDP has trended upwards since the 1950s. R&D expenditures have grown particularly strongly since the early 1980s (Figure 1). By 1998, industry-funded R&D reached $144 billion, representing 1.7 percent of GDP - up from one percent or less throughout the 1960s and 1970s. R&D spending by private industry is expected to continue its strong growth in 1999 with a nine-percent increase, according to the Industrial Research Institute.[9]

The rise in industry-funded R&D in the past two decades can be contrasted with a substantial decline in federally-funded R&D during the same time period. Figure 1 indicates that federally-funded R&D that is performed by industry has fallen dramatically since the 1960s, when measured as a percentage of GDP. R&D that is both federally-funded and federally-performed has also trended downwards since the 1960s. Much of the decline in federal R&D is attributed to a reduction in federal defense research.

A portion of the long-term growth trend in industry-funded R&D is likely attributable to the general rise in wealth and sophistication of the U.S. economy. As economies have become more technologically advanced during the 20th century, R&D seems to have become more central to the economic growth process.[10] Cross-country statistics show that R&D expenditures as a percentage of GDP increase as a country=s GDP per capita increases.[11]

The particularly strong growth in industry-funded R&D since the early 1980s may be attributable to a number of factors. Domestically, lower regulatory costs and higher competition in many U.S. industries has spurred technology investment.[12] In addition, increasing global economic integration has meant that U.S. businesses face greater competition than ever before. Businesses subject to increased foreign competition must invest heavily in R&D in order to stay ahead of leading-edge competitors in Europe and Japan. The relative increase in foreign technological sophistication is indicated by the fact that the U.S. share of world R&D has fallen from 70 percent in 1960 to 43 percent today.[13]

Business R&D expenditures are pro-cyclical B rising during expansions and falling during recessions.[14] U.S. R&D expenditures grew strongly during the 1980s boom, dipped during the early 1990s recession, and have since rebounded strongly. The surge in corporate profits in recent years has providing companies with the resources to fund large R&D investment programs, and has created expectations for a high investment payoff from R&D. Another factor explaining high R&D spending in the 1990s are lower interest rates which have lowered the cost of funds for R&D investment.

Along with the rise in industry R&D expenditures, the number of scientists and engineers employed by R&D-performing companies has grown strongly since the mid-1990s.  See Figure 2.

## B. R&D-Performing Industries

The growth trend in U.S. industry R&D is particularly impressive given the underlying shift in the economy away from manufacturing and towards services industries.  Traditionally, the nonmanufacturing sector as a whole has spent a lower proportion of revenues on R&D than manufacturing.  But that is changing, and in recent years nonmanufacturing has accounted for an increasing share of total industry R&D.

Figure 3 shows NSF data for industry-funded R&D for 1997.  The manufacturing sector performed 76 percent of industry-funded R&D in 1997.  The nonmanufacturing sector performed 24 percent of industry R&D in 1997 B up from just 8 percent in 1987.

The largest R&D-performing industries within manufacturing are: electrical equipment, transportation equipment, machinery (which includes computers), and chemicals (which includes pharmaceuticals).

The largest R&D-performing industry within nonmanufacturing is business services, which includes computer and data processing services

While Figure 3 shows the largest R&D performing industries in terms of total dollars spent, Figure 4 shows the most research-intensive industries B those with the highest research-to-sales ratios.

Within manufacturing, the most research-intensive major industries are instruments, electrical equipment, machinery, chemicals, and transportation equipment. Within these major industries, sub-industries which are particularly research intensive include pharmaceuticals, office machines and computers, electronic components, and communications equipment.

Within nonmanufacturing, the most research-intensive major industries are business services (and one of its sub-industries, computer and data processing services), engineering and management services, and health services.

## C. U.S. R&D in Comparison to Other Countries

Levels of U.S. R&D expenditures are often compared to R&D expenditures in other industrial countries in order to judge the adequacy of the U.S. effort.  Concern has been expressed in the past that U.S. non-defense R&D spending relative to GDP is below that of Japan and Germany. While this concern has been tempered somewhat in recent years because of the poor performance of the Japanese and German economies, high levels of R&D spending in those countries does indicate that their leading-edge industries will continue to be strong competitors to U.S. producers.

Figure 5 shows that U.S. nondefense R&D spending represented 2.15 percent of GDP, compared to 2.74 percent in Japan and 2.20 percent in Germany. Note that these figures includes both industry-funded and non industry-funded R&D expenditures.

Caution should be used when making R&D comparisons between countries because numerous factors contribute to the observed differences. These factors include the industrial structure of a country, the quality of available scientists and engineers, the quality of physical infrastructure, a country's proximity to major markets, its tax and regulatory policies, and the level of patent protection.

## III. R&D AND THE ECONOMY

### A. The 20th Century Fusion of Science and Business

Advances in knowledge have always been central to the economic growth process. Before the industrial revolution, advances in knowledge were left to small-scale artisans and tinkerers who improved traditional methods of producing goods by ad-hoc experimentation. Until the late 1800s, scientific research was generally separated from the concerns of the business sector and did not affect the standard of living of most of the people.[15] For example, early discoveries in astronomy or mathematics did little to improve the general standard of living for many centuries.

But scientific advances in a variety of fields, notably chemistry and electricity, in the late 19th century started to profoundly change the path of economic growth.[16] For the first time, businesses began to establish scientific research labs to create new and better products in a systematic fashion. Science and business came together for the first time.

An early example of the enormous growth potential of organized industrial R&D was demonstrated by the newly-established chemistry laboratories by steel manufacturers and railroad companies in the 1870s. Breakthroughs in metallurgy from these labs increased the life of a steel rail from two to ten years, and the weight that rail could bear increased over eight times by 1905.[17] Thus chemistry R&D played an important role in the huge economic impact created by the railroad revolution.

Today, discovery of better ways to make goods and services to improve our quality of life has become a very structured and specialized process B AR&D.@ However, the aim of early artisans, and the modern R&D scientist or engineer, is the same - to discover new and better goods, and to produce them with less worker effort, less time, and fewer material inputs.

Since the first fusion of scientific innovation and business enterprise over a century ago, the complexity of the modern economy has grown enormously. As a result, R&D has become ever more central to the economic growth process.[18] As evidence that this trend has accelerated in recent years, the OECD notes that inventions, as measured by patents, are increasingly relying on newly-discovered knowledge from basic science breakthroughs.[19]

While high-tech, science-based industries are increasingly important in the U.S. economy, non high-tech industries have a growing reliance on scientific research as well.[20] As the Council on Competitiveness notes, today there are A... no >low-tech= industries B only low technology companies that fail to incorporate new ideas and methods into their products and process.@[21] As a consequence, R&D and technological advances can have broad ripple effects across many industries.

The broad ripple effects show up in macroeconomic indicators. As noted by the

OECD, Awhether they decrease prices or create new products, innovations result in higher wages and profits, thus increasing real incomes, demand for goods as well as services, and, consequently, creating jobs.@[22]

## B. Measuring the Contribution of R&D to Growth

While it has been clear during this century that scientific discovery has led the American economy towards higher standards of living, economists have had a difficult time accurately measuring the contribution of technology and R&D to the nation's economic growth. Traditional "neoclassical" economic theory relates growth in GDP to growth in the capital stock (e.g. buildings and machines), and growth in the quantity and quality of labor.

Studies of this type in the 1950s and 1960s found that about half of U.S. GDP growth could be explained by growth in capital and labor.[23] The remaining 50 percent was an unexplained Aresidual@ and was attributed to technological progress. The U.S. Office of Technology Policy noted that technological progress Ais the single most important factor in generating sustained economic growth, estimated to account for as much as half of the nation=s long-term growth over the past 50 years.@[24]

The technological progress Aresidual@ is a measure of Atotal factor productivity@ (TFP). Increases in TFP stem from innovations which allow producers to squeeze more output out from given levels of capital or labor input. A primary source of such innovations is R&D. But growth in TFP also stems from improved business management, removal of inefficient government regulations, and other factors.

Since the initial studies on the sources of GDP growth, numerous studies have incorporated better measurements of capital and labor which reflect quality improvements in these two inputs. After all, businesses generally replace old machines with new machines that have more capabilities than the old ones. With these quality-adjusted measures of capital and labor, some studies have provided lower estimates of the contribution of technological progress to post-war growth of about 25 percent.[25]

At first blush these new lower estimates of the technological progress residual seem to suggest a smaller contribution of R&D towards U.S. economic growth. But numerous economists have noted that R&D directly increases the quality of inputs to production. Capital investment in new machines often incorporates the latest technological advances from R&D. So R&D both increases TFP, and it increases U.S. economic growth through the process of capital investment.[26] One estimate reported by the Council of Economic Advisors is that R&D investment accounts for about half of the growth in U.S. GDP per capita.[27]

But despite many statistical studies, the relationship between technology and economic growth still contains many puzzles, including the "productivity paradox." U.S. productivity growth since the early 1970s has been lower than during the 1950s and

1960s - despite the waves of innovations unleashed by the computer revolution. Some economists attribute the productivity slowdown to mismeasurement problems. Others have noted that increases in R&D and technological advances often take many years, perhaps decades, to be Adigested@ into an economy before growth rates rise.[28] Companies may be hesitant to make expensive purchases of technologically-advanced machines, particularly if labor force retraining is necessary. Historians have noted that delayed growth effects were evident after such technological revolutions as steam and electrical power.[29]

The most recent economic data indicates that the productivity paradox may have ended. In the past three years, labor productivity has grown at 2.2 percent per year, compared to just 1.3 percent on average since 1973. Federal Reserve Chairman Alan Greenspan recently noted that "evidence for technology-driven acceleration in productivity is compelling, but not conclusive."[30] Optimists believe that the massive investments in information technologies by the business sector during the 1990s may now be showing up in strong productivity and economic growth.

This section has identified factors that are traditionally used to explain economic growth B capital, labor, technology, and R&D. It should be noted, however, that underlying all these factors, is a precondition of a hospitable Asocial infrastructure.@ [31] Unless a country enforces the rule of law, has strong intellectual property rights, and moderate taxes and regulations, they may have legions of R&D scientists, but little economic growth. The OECD notes that another Aframework@ condition to maximize the technology-growth linkage is providing for maximum competition in markets.[32] They note that competition drives firms to invest in technology in order to maximize profits, and that Acreative destruction@ ensures that the highest productivity firms survive, while companies that fail to innovate go by the wayside.

## C. Product and Process Innovations

In a market economy, the reward for successfully innovating businesses include lower production costs, higher sales, and higher profits. Businesses can pursue these rewards through: i) product innovations aimed at discovering new and better products, and ii) process innovations aimed at improving production efficiency. Both types of innovations are crucial to sustaining U.S. long-term growth.[33]

The financial payoffs from innovations may be large, but today=s competitive marketplace ensures that advantages are unlikely to be permanent. Higher profits signal the success of an innovation and prompt competitors to join the field. Patent protection and trade secrets may provide temporary shelter for innovating businesses. But in today=s dynamic marketplace, in won=t be long before competitors Areverse engineer@ new technologies, and invent around patents in order to create similar products.

***Product Innovations***

There is a long list of now common products that Americans rely upon which were created in the nation=s industrial R&D labs including Dupont=s Nylon in 1935, Intel=s microprocessor in 1971, and Eli Lilly=s Prozac in 1988. The economic importance of R&D to the economy is evident when one considers that these and other inventions have spawned whole new industries with billions of dollars in sales.

Today, R&D is spurring creation of many new Ainformation technology@ (IT) industries. According to the U.S. Department of Commerce, IT industries accounted for 8.2 percent of U.S. GDP in 1998 and generated for over a quarter of real U.S. GDP growth during the past five years.[34] The computer manufacturing industry, for example, was nonexistent in 1950, but had revenues of $431 billion by 1997.[35] Meanwhile, employment in computer-related service industries, such as software, has doubled in just the past seven years and totaled 1.6 million by 1998.[36]

Many of the most R&D-intensive industries are also the fastest-growing. For example, while U.S. manufacturing GDP rose 55 percent between 1987 and 1997, GDP in electrical equipment rose 89 percent and GDP in chemicals rose 87 percent.[37] Among nonmanufacturing industries, business services and health services are both fast-growing and R&D-intensive.

Aside from developing wholly-new products, much of business R&D aims at incremental improvements in existing products. For example, automobile industry R&D led to the creation of anti-lock braking systems thus increasing automobile safety, and better automobile pollution control devices have dramatically improved the air quality in American cities. Such improvements certainly add to our quality of life, even though they are often not fully-reflected in GDP growth statistics

***Process Innovations***

While it is easy for American consumers to appreciate R&D breakthroughs which put new products on store shelves, U.S. living standards are also raised by business innovations which lower the costs of existing goods and services. R&D can allow a company to produce more output with less labor, fewer material inputs, less time, greater safety, and with a smaller impact on the environment.

Agriculture provides a dramatic example of an industry in which R&D has played a central role in improving production efficiency. Farm yields have radically increased this century from scientific innovations in crop genetics, pesticides, and other advances. In 1890, it took about 40 hours of labor to produce 100 bushels of wheat or corn, but just three hours of labor a century later.[38] Gains in dairy farming are also impressive. In the past three decades, the nation=s dairy herd has fallen by one quarter while milk production has increased by more than one-third.[39] In total, Department of Commerce statistics show that farm total factor productivity (farm output per unit of labor and machine input) is four times greater today than in 1900.

## D. ASpillover@ Benefits of R&D

A principle reason why R&D is important to the economic growth process is that it generates Aspillover@ benefits. The benefits of an innovation made by one company can spread broadly, or spillover, to many industries throughout the economy. For example, a cost-reducing production technique may be copied or adapted for use by companies in many industries.

The existence of spillover benefits explains why studies find that investment returns from R&D to the economy as a whole are often greater than the returns to investing businesses themselves. The President's Council of Economic Advisors has summarized the results of these studies.[40] Estimates for the private rate of return to R&D average about 25 percent. Estimates of the rate of return from R&D to the economy as a whole are in the order of 50 percent or more. So the rate of return from R&D to the economy as a whole may average about twice as high as the rate of return to the original investor.

Spillover benefits from innovations may flow from either "<u>customer</u>" or "<u>knowledge</u>" spillovers.[41]

***"Customer" Spillovers***

Businesses seek to discover new products and better production techniques in order to earn higher rates of return. But customers of an innovative firm may often be the largest beneficiaries of breakthroughs. Customers may value a new or higher-quality product from a supplying company much more than what it costs them to purchase. In that case, some of the benefits of the innovation Aspillover@ onto the purchaser.

Consider, for example, a manufacturing company that saves millions of dollars from a new computerized inventory system that cost, perhaps, only a few hundred thousand dollars to purchase. The supplying company, the manufacturing company, and the ultimate consumers could all potentially receive a financial benefit from such an innovation.

Such customer spillovers are one reason why globalization is becoming more important to the U.S. economy. An increasing share of world trade is in high-tech products where R&D plays a crucial role.[42] Globalization means that technological advances abroad can boost the efficiency of U.S. producers from purchases of intermediate goods such as advanced manufacturing machines. In a recent study on technology, the OECD found that Atechnology embodied in imported capital and intermediate goods has contributed significantly to productivity growth.@[43]

***"Knowledge" Spillovers***

In order to earn a return on investment and to gain competitive advantage, most companies are careful to guard trade secrets and secure patents for their intellectual property created through R&D. Nonetheless, scientific advances often do eventually get diffused broadly in the economy through Aknowledge spillovers.@ For example, scientific knowledge discovered by one firm may be shared in academic journals and at industry conferences. In this case, many businesses, perhaps in numerous different industries, may receive a Aknowledge spillover@ that helps their own firms produce better products.

Knowledge spillovers may take place through numerous other channels. Technical information is often shared with both suppliers and customers of a firm. Scientists move their employment between firms and between industries, and bring their expertise with them. In addition, businesses are increasingly taking part in research alliances and joint ventures with other firms and universities in order to quickly gain access to the latest pools of knowledge.[44]

While patents and trade secrets do limit the legal transmission of new production knowledge, competing businesses often Areverse engineer@ and invent around patents held by other businesses, and produce products with similar characteristics. One study found, for example, that 60 percent of patented innovations were imitated within four years.[45] Intellectual property that is held securely, is nonetheless, often shared by licensing mechanisms with the result that innovations are diffused quickly to the economy through many channels.

## E. R&D and U.S. Business Competitiveness

***Technology is a Key to U.S. Business Competitiveness***

As foreign competition was increasing during the 1970s and 1980s, there was much concern about the competitiveness of U.S. businesses. But that picture has changed in recent years as many U.S. businesses have restructured themselves, and as foreign economies have faltered. Today, cross-country surveys of business environments and business management skills routinely place the U.S. business sector as the most competitive of the major industrial countries.

For example, the World Economic Forum=s 1998 report gave U.S. industry especially high scores in the level of technology utilized and the quality of business management.[46] These two factors, for example, were key to the turnaround of the U.S. automobile manufacturing industry.[47] Automobile industry measures of productivity, such as average hours to manufacture one vehicle, have steadily improved towards Japanese levels.

Large investments in R&D and advanced technology have played a key role in turning around many other U.S. industries.[48] Application of computer technology has allowed companies to reduce inventory costs with just-in-time manufacturing systems, and allowed businesses to respond more quickly to customer needs with more frequent product and service redesigns.

The high level of technological sophistication of many U.S. manufacturing industries allows them to successfully compete with firms anywhere in the world. The Council on Competitiveness notes, for example, that Athe historical success of U.S. agriculture in international markets is due in no small part to the development and application of advanced technologies specific to the agriculture sector, including farming techniques guided by computers and agricultural biotechnology.@[49] And because technology makes U.S. workers the most productive in the world, they can easily compete with firms in low-wage countries. The average American worker can, for example, produce as much in ten days as the average worker in Niger produces in an entire year.[50]

***Global Markets Allow U.S. Companies to Fund Large R&D Budgets***

While increasing levels of globalization and foreign competition has been a threat to some U.S. producers, most U.S. businesses have also treated it as an opportunity. For example, globalization has been an important factor fueling the rise in U.S. industry R&D spending in the 1990s.[51] High levels of R&D spending have become a necessity in many industries to prevent falling behind in world markets. In fact, the bulk of U.S. R&D is performed by the large multinational corporations (MNCs) which compete around the globe against leading-edge companies based in other advanced countries.

Foreign sales are often crucial for U.S. companies to sustain a large R&D investment program. The value of an innovation created by a firm=s R&D increases in proportion to the size of the market in which it can be used. Higher sales ensure a larger potential payoff to new product breakthroughs and thus encourage companies to take extra risks and pursue greater investment in promising ideas. If such innovations can be protected either by patents or as trade secrets, large markets give firms large incentives to make breakthroughs.

American firms used to hold a somewhat unique advantage because of the large domestic U.S. market. American=s R&D success can be explained by "the uniquely large American market of the late nineteenth and early twentieth centuries offered the innovator much greater potential returns than, say, a medieval market limited to a single city."[52] Indeed, economic growth theorist Paul Romer finds that because America=s internal market was larger than that in Britain and other advanced countries, it was a key factor in our more rapid technological advancement and economic growth.[53]

But with an increasingly integrated world economy, American firms are no longer unique as firms in all countries can gain the size advantage of trading in the world market. Globalization is thus creating an imperative for U.S. policymakers to create the best possible climate for R&D and technological investment in order to maintain the United States= leadership position.

***Creating a Good Climate for R&D in the United States***

Globalization not only creates world-wide markets for the new goods and services created by R&D, it is also slowly creating a worldwide base for the R&D activities of global corporations. For example, the Department of Commerce found that by 1995, there were 645 foreign-owned research facilities in the United States including Japanese automobile companies, Korean computer companies, and Canadian telecommunications companies.[54] U.S. corporations also operate R&D facilities in other countries, although the bulk of their R&D is carried out domestically.

As the world economy becomes more integrated, multinational corporations could potentially perform R&D in any number of countries which have a supply of well-trained scientists and engineers. And policymakers in many countries seek to attract high-tech and R&D activities to their shores for many reasons.

R&D activities create high-paying jobs in Aknowledge@ industries. The Department of Commerce found that in 1996 workers in Ainformation technology@ industries earned 70 percent more, on average, than all U.S. private sector workers.

Also, R&D helps businesses penetrate global markets by creating innovative new products and lowering production costs. As noted, an increasing share of world trade is in high-tech products where R&D plays a crucial role.[55] In addition to traded goods, R&D creates intellectual property which when licensed abroad creates inflows of royalties and fees into the domestic economy.

## IV. CONCLUSION

With an increasingly integrated and competitive global economy, U.S. businesses are finding that they must fund large Aknowledge investments@ in order to stay competitive. Industry-funded R&D has risen 70 percent since the 1970s with the goal of improving production efficiencies and creating innovative new products.

A complementary trend which emphasizes the rising importance of knowledge investments is the rising business investment in information technologies (AIT@). For example, investment in computers and peripherals have risen from six percent of total business equipment investment in 1980, to 14 percent in 1998. Investment in all IT equipment now represents over one-third of business equipment expenditures.[56]

Such heavy knowledge investment by U.S. industry appears to be paying off. Federal Reserve Chairman Alan Greenspan and other economists have linked strong productivity growth in recent years to the advances made in U.S. technology industries.[57] Also, many U.S. industries that are very R&D-intensive, such as semiconductors and biotechnology, dominate world markets for their products. For example, the U.S. biotechnology industry, which spends 50 percent of its annual revenues on R&D, is over five times larger than the entire European biotech industry.[58]

The challenge for policy-makers is to ensure that the United States continues to be the most favorable location for R&D activities for tomorrow=s knowledge industries. This means, in part, making sure that federal tax policies, regulatory policies, and other factors create the best possible business climate for R&D. The on-again, off-again R&D tax credit has not been as favorable to U.S. R&D investment as a permanent credit would be. But with improved policies, such as a permanent and effective R&D credit, America=s pre-eminence in industrial research and high-technology industries will continue far into the next century.

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***This staff report reflects the views of the author only. These views do not necessarily reflect those of the Joint Economic Committee, its Chairman, Vice Chairman, or any of its Members.***

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