

## SUMMARY

## INTRODUCTION

This report is concerned with the relationship between Government action and technological innovation in the civilian sector of the U.S. economy. Its principal objective is to develop some of the key policy issues important in designing future programs affecting innovation. These issues are concerned with promoting technological innovation for economic purposes, using innovation to achieve a variety of social goals, and controlling the adverse consequences of new technology. The issues have been derived from several research components: consideration of the appropriate role of Government in the technological innovation process (chapter 11); a knowledge of the range of current U.S. Government actions bearing on innovation and an understanding of the innovation process and how industry responds to such Government interventions (chapter III); and an acquaintance with the experience of comparable industrialized nations in fostering technological innovation (chapter IV). The result of the analysis is not to prescribe specific legislative actions for Congress, but to suggest broad areas where Congress might consider programs in the future to reinforce the momentum or influence the direction of U.S. technological development.

## THE GOVERNMENT ROLE IN THE INNOVATION PROCESS

Governments in all modern industrialized countries employ a variety of techniques to promote and shape technological development. Each has concluded that the free action of the market is not sufficient to achieve the desired long-term goals of technological strength and independence. For many different reasons, governments may choose to intervene where market forces are clearly incapable of achieving defined national objectives.

First, with respect to knowledge generated from the research and development process, private economic units cannot capture all the benefits arising from the creation of new knowledge and will tend to invest in those projects whose results they can control. Similarly, in some cases, like public health, few economic units benefit from research investments. Hence, from the societal point of view, underinvestment in important research areas may occur because of the nonappropriable or public nature of knowledge.

Second, while some larger companies in the United States may invest vast amounts of resources in research and development, the limited scale of most private economic units prohibits their undertaking very large-scale research. Hence, Government performance or support of some kinds of R&D as well as many forms of basic research is necessary.

Third, the public interest often requires a Government role to shape and control the social and political nature of new technological development. The private sector, responding to market signals other than social priorities, cannot be expected to ensure the welfare of society and the Nation. This situation may require regulation to correct market failures (for example, pollution control) or substitution of social decisions for the market allocation of resources (for example, transportation facilities for the elderly and the handicapped).

## U.S. EXPERIENCE

The task of documenting the current content and effect of U.S. Government policy toward innovation has been approached from two perspectives. Part of the analysis concentrated on identifying and categorizing existing Government programs. A parallel effort attempted to illustrate some of the effects of Government programs in selected industries. The utilization of these two perspectives is based on an important premise of this report—that a full understanding of the Government-innovation relationship involves not only a knowledge of existing programs but also of the industrial contexts in which their impacts occur.

### Government Programs

The number and variety of Government programs affecting innovation is very large, although many, if not most, are not necessarily designed with that goal in mind. On the contrary, they are directed toward goals as disparate as economic growth, job security, and environmental quality. It is useful and necessary for conceptual purposes to establish a framework for organizing these actions into a number of self-contained program areas which reflect the major technology-related themes of current Government policy. Such a framework can (1) provide a convenient analytical framework for viewing the programs, (2) illustrate the programs' relationships to technological innovation, and (3) furnish a common structure within which proponents of different viewpoints can make a case for reorientation of national policy regarding technology.

The framework developed for this report is shown in table 1.

For each area, the existing programs have been identified and categorized. This is done through the use of 13 matrices (see pp. 23-25), whose headings illustrate some aspects of the relationship of the programs to innovation. This categorization was useful to the research effort in that it highlighted areas of current program emphasis and neglect. Conclusions of this nature, reached from the matrices, were used as a major source of input to the development of the key policy issues presented in chapter V.

**Table 1.—Thirteen Program Areas**

Area	Program
I.	The assessment of new and existing specific technologies.
II.	Direct regulation of the research or development of new products and processes.
III.	Direct regulation of the production, marketing, and use of new or existing products.
IV.	Programs to encourage the development and utilization of technology in and for the private goods and services sector.
V.	Government support of technology for public services where consumers are the primary users.
VI.	Support for the development of technology where the Federal Government is the primary user.
VII.	Support for the science base necessary for the development of new technology.
VIII.	Policies to affect industry structure that may affect the development of technology.
IX.	Policies affecting supply and demand of manpower resources having an impact on technological change.
X.	Economic policies with unintended or indirect effects on technological innovation.
XI.	Policies affecting international trade and investment.
XII.	Policies intended to create shifts in consumer demand.
XIII.	Government policies responding to worker demand having impact on technological change.

### A Comparison of Selected Industry Experiences

The experience in several industries has been reviewed to determine the nature of the impact of Government actions on the innovation process. From this sample of industries, three policy instruments emerge as the most effective Government policies in influencing the rate and direction of technological change:

- Regulation (pollution, health and safety, energy conservation);
- Federal R&D support (direct to industry, indirect, and Government-performed); and
- Procurement of innovative technology-based products.

In general, these industry studies have shown that several characteristics of Government ac-

tions have made them particularly effective in promoting technological innovation. First, Government programs and incentives that help new firms and ventures get started normally have resulted in important innovative activities in various sectors. Second, where the Government has provided a market for new technologies or has given direct R&D support, firms have frequently responded by changes in products and processes as a result.

Third, actions that complement normal competitive pressures for change in an industry have been effective in inducing technological change, largely because they have taken into account the force of the market on innovations. For example,

regulations with respect to energy conservation have reinforced normal market forces to stimulate new fuel conservation innovation.

Fourth, while Government performance of basic research has made many outstanding contributions to industrial innovation, evidence shows that Government development per se of new products and processes has often been overtaken by the rapid pace of innovation in private industry where superior knowledge of the production process and product design prevails. This observation leads to the conclusion that Government action of this nature is most effective where it complements normal market forces operating within the private sector.

### KEY FEATURES OF GOVERNMENT SUPPORT FOR TECHNOLOGICAL INNOVATION IN SELECTED FOREIGN COUNTRIES

While there exists no clear equivalent to the U.S. experience among foreign countries, the success and failure of government involvement in the innovation process abroad can be instructive to U.S. policy makers. In analyzing the major features of programs in Japan, the United Kingdom, West Germany, and France, several clear contrasts in philosophies and tactics with respect to encouraging technological change are apparent. In particular, the relative success of certain Japanese approaches and the lack thereof of several British programs may offer interesting lessons for future U.S. programs. On the whole, however, several common elements tend to emerge in observing the approaches of these four case countries, namely:

- Direct government support for product development and R&D in private firms tends to be a prominent instrument in stimulating innovation abroad.
- Government support for technological developments basic to a wide range of industry is almost ubiquitous (e.g., friction research).

- Use of government procurement is relied on to strengthen demand for innovative technologies and reduce market risk and uncertainty for firms.
- *Provision of capital* by the government to firms seeking to introduce innovative products and/or processes is present in all these countries, although the form and timing differs from case to case.
- Emphasis on changes in industrial structure is apparent in all four countries in order to meet the requirements of technological progress and international competition.
- Emphasis on export performance in international markets is a clear priority in all these countries, and is translated into several types of incentives for new products and processes.
- Emphasis on labor training and manpower development policies constitutes a major feature in the technology development policies of these countries.

### ISSUES IN FUTURE U.S. GOVERNMENT POLICY TOWARD TECHNOLOGICAL INNOVATION

On the basis of what is known about current U.S. policy toward technological innovation, in-

dustrial response to these programs, and the insights gained from foreign experience, several

policy issues have emerged which, in the author's opinion, merit consideration by Congress. The following summarizes these issues and some illustrative, although far from exhaustive, initiatives which may derive from them.

## ISSUE 1

### Direct Support of Non mission-Oriented Technology

Currently, the U.S. Government provides no direct support for nonmission-oriented technological development, unlike other industrialized countries where this support is frequently prominent. There are several reasons for considering such support. First, the United States is facing growing competition in international markets in technology-based products from countries where Government support for such technologies is strong. Second, the social returns on technological innovation are frequently greater than those accruing to the individual inventor and may take the form of increased employment, environmental protection, and product safety. Therefore, there are many areas in which the private sector will underinvest in the development of new technologies because of the inability of the developer to appropriate the rewards. Congressional initiatives for the implementation of a policy to support the development of such technology might include:

1. Legislation directing the procurement of innovative products at a price that provides for an indirect subsidy of R&D costs;
2. Support for a program of advanced research responsive to a variety of social goals, but not appropriable by any single firm; and
3. The granting of exclusive patent rights to individuals and firms making inventions on federally supported R&D programs.

## ISSUE 2

### Reconsideration of the Role of the National Laboratories

Most of the existing National Laboratories were set up to support a specific governmental

mission such as nuclear weapons development or space research. In many instances, however, these laboratories have expanded their roles beyond the original missions. In other cases, the changing nature of Government policies has brought on changes in their activities. At present, many of the National Labs compete directly with private industry in performing research directed at the development of civilian technology of commercial significance. Options available to Congress to better utilize the National Laboratories include:

1. The definition of explicit missions, as well as the identification of, and justification for, new research roles for them; and
2. Development of guidelines for use by the funding agencies in deciding which projects to fund in-house and which to support in the private sector.

## ISSUE 3

### Facilitating New Entrants Into the Market

New and small firms have been shown to be leading innovators in many areas, largely because they are often formed on the basis of a new idea or product and have great flexibility in introducing radically new products into the market. Such firms frequently face a variety of barriers in establishing or expanding their operations, including restrictions on venture capital, tax disadvantages (including less favorable than before capital-gains taxation), regulatory barriers, and market dominance by larger, established firms. Congress might usefully consider several options to ease the process of entering the market for new firms and individual entrepreneurs, such as:

1. Selective use of Government procurement policy;
2. Stricter enforcement of antitrust laws;
3. Assistance to new firms in meeting regulatory requirements; and
4. Greater patent protection for the small innovator.

## ISSUE 4

### Diffusion of Technology Within the Private Sector

Better diffusion of existing technologies and existing technical information would serve to stimulate innovation in several ways. First, the productivity levels of industries could be raised by closing technology gaps. Second, by helping small- and medium-size firms compete with larger ones, new innovative products and processes could be encouraged. Third, compliance with regulation could be facilitated by diffusing knowledge of the means to comply. Finally, new uses of technologies could be promoted by transfers among different types of industries. Existing market structures tend to inhibit wide application of technologies, thereby giving undue advantages to large technology leaders. Several instruments are available to the U.S. Government to overcome such market rigidity, some of which might be:

1. Establishment of a network of local technical centers;
2. Support for industrial cooperative activities by small firms;
3. Support for technology information/communications systems;
4. Compulsory licensing of technologies to competitors when leading firms reach a certain market share; and
5. Government purchases of technology for resale to new users.

## ISSUE 5

### Implementation of Environmental and Safety Regulations

The effect of regulation on technological innovations remains highly controversial. The research which has been undertaken in this area indicates that the effects which exist, though substantial, cannot be simply characterized. At a minimum, it is necessary to recognize both positive and negative impacts and to distinguish the effects of regulation on the development of new compliance technology from the more general effects that it may have on the rate and direction of technological innovation in the broad sense. In-

sufficient attention has been given to new means of implementing regulatory legislation so as to encourage innovative compliance technologies that help to achieve regulatory goals. For example, the following regulatory mechanisms, among others, deserve consideration in the U.S. context:

1. Strict liability for pollution damage;
2. Effluent taxes;
3. Joint R&D for pollution control; and
4. Government support for the development of compliance technology.

Evaluation of the means to promote innovation in regulatory compliance is needed as well as immediate application in selected contexts of new policies to facilitate the achievement of regulatory goals via technological change.

## ISSUE 6

### Manpower Resources, the Labor Market, and Technology

An infrastructure element essential to technological change is qualified manpower. The rapidly changing nature of technology requires a flexible and farsighted manpower policy to prepare for future technological development, both in terms of training for the future and helping workers adjust to the dislocations that are frequently caused by technological change. A comprehensive manpower policy adopted by Congress might include several important components to satisfy these needs, such as:

1. An analytical capacity within Government to conduct continuing forecasts of future skill requirements in different sectors;
2. An effective program of labor adjustment assistance to facilitate the adaptation of workers and their skills to new job requirements; and
3. A long-term strategy for scientific and technical education and training adapted to future manpower needs and technological trends, particularly in the area of engineering education.

## ISSUE 7

### International Commerce and Domestic Innovation

Technological innovations are vital to U.S. industries in competing with foreign producers in both international and U.S. markets. Government efforts are needed to help U.S. industries enhance their competitiveness by promoting domestic innovations as well as facilitating the adaptation and improvement of advanced foreign technologies. For industries that are non-competitive in the long run, Government measures are needed to assist labor and business adjust structurally and to soften dislocations during the transition.

## ISSUE 8

### Support for Sector-Specific Microanalysis

The relationship between Government action and technological innovation varies significantly among different industrial sectors. Because there is a lack of good studies of specific industries and the effects of Government programs on them, Government policymaking in various areas is often severely hampered. No sector-specific microanalytical capability of significant size exists in Government today. Consideration should be given to support for such a capability to aid decisionmaking in areas ranging from regulation to tax policy. This capability need not necessarily be lodged in the Government, but could also successfully be established with Government support in universities or other parts of the private sector.

## ISSUE 9

### Support for Hazard Analysis

Because hazards too often go unrecognized until their dangers reach crisis proportion, it is im-

portant to create a capability to anticipate them, or at a minimum, to institutionalize a means to monitor their presence. Although various agency programs attempt to assess and prevent hazards, the existing efforts are deficient in several respects. Hazard analysis as currently performed in Government lacks coordination and is not contained within the explicit mission of many agencies. Consequently, it is an underdeveloped discipline. Several policies deserve consideration, including:

1. A centralized agency to strengthen the U.S. hazard analysis capability;
2. Government support for development of this discipline in universities, worker, and consumer education; or
3. A hazard analysis requirement for industrial firms.

## ISSUE 10

### Affecting the Demand for New Technologies

Perhaps as a result of the overemphasis on R&D as a component of the innovation process, Government policy to date has tended to focus more on the supply of new technologies than the demand. However, policies that work through influences on demand have often been shown to be more effective in eliciting innovative products and processes. Government procurement is one notably successful example, and environmental regulation may sometimes work in a similar fashion to change demand. New demand-oriented policies should be considered, including mechanisms that create new or expanded markets, for certain kinds of technologies, e.g., procurement, user subsidies, regulations; and mechanisms that directly influence consumer demand, e.g., information provision or advertising regulation.