Chapter V

MAJOR ISSUES IN U.S. POLICY TOWARD TECHNOLOGICAL INNOVATION

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This chapter presents a series of policy issues concerning the relationship between Government action and technological innovation which are, in the authors' view, major questions deserving of congressional attention in the near future. The articulation of these issues is intended to provide a critique of existing U.S. programs and policies in relation to innovation and to provoke debate about how existing policies might be reoriented. It should be acknowledged from the outset that the choice of these issues was at least partially subjective. Thus, reasonable people will undoubtedly differ about how important they are for congressional attention. It is not meant to imply that these issues are necessarily more important than other national priorities. Rather, they are intended to suggest a series of new initiatives that merit consideration in reassessing existing technology-related policies.

Although the issues involve subjective choice, the process for arriving at them was rooted in objective research. Thus, they derive principally from the three major elements of this report, the survey of existing Government programs, industry studies (chapter Ill), and foreign experience (chapter IV). The survey and categorization of existing U.S. programs furnished a framework within which to understand the relative emphasis among major policy areas and, within each policy area, to uncover what kinds of policy mechanisms have been employed most frequently for various purposes. From this survey it was possible to derive policy areas and mechanisms which, although now relatively neglected, may deserve additional attention in the future. The industry studies, on the other hand, provided information about how existing programs have actually affected innovation in those industries and therefore offered guidance as to what kinds of new or modified Government actions are likely to be effective in different contexts. Finally, the survey of foreign experience offered case studies of effective and ineffective techniques employed by other governments to encourage their private firms to innovate (see figure 2).

The purpose of this chapter, therefore, is to define these major issues, articulate why they appear to be important, and then to suggest a series of alternative policies which address the issues in various ways. The **alternatives suggested are not meant to be an exhaustive** list, nor is advocacy intended. They are suggested in order to illustrate the action potential inherent in each issue. It is intended that the focus of debate will be primarily on the issues themselves and only secondarily on the possible alternative actions.

ISSUE 1
Direct Support of Non mission-Oriented Technology

Should Congress consider providing for the direct support of nonmission-oriented technology?

Direct Federal support for technological innovation has traditionally taken one of two forms in this country: general support for research and development, such as that funded by the National Science Foundation (NSF), and support for technology development (through R&D funding and the procurement of innovative products) in furtherance of certain well-defined national goals, such as the defense and space missions, and more recently the search for new sources of energy (see program areas IV, V, VI, and VII in chapter III).

This policy differs markedly from the practice and procedures of other technologically advanced nations, notably Japan, in which the governments support technological innovation with no other goal than the general economic one of helping particular sectors of industry to grow and to compete in international markets (see chapter IV).

Increased attention has recently been focused within the Government on ways in which, in cooperation with the private sector, it might seek to stimulate and encourage technological innovation through programs of direct support of some kind. There are three basic reasons for the heightened interest in such programs. First, the United States is facing increasingly stiff competition in technology-based products from other nations that have programs for domestic support of technological innovation for purely economic purposes.

In addition, the social returns on technological innovation are often greater than any reasonable expected private return, due to the inappropriability of some of the benefits, which makes a Federal sponsorship role appropriate (see chapter II). Lastly, there are purely social reasons for supporting innovation. An example of these is the general desirability of creating employment. Support for new development with specific manpower benefits in mind may involve both technological innovation and job redesign, and differs from the application of traditional labor market policies (discussed in issue #6). Technological innovation may also be supported for reasons of environmental protection or product safety.

If the Federal Government were to adopt a policy of broad support for technological innovation, the question would arise as to what type and degree of Federal intervention is appropriate and necessary at each stage of the innovative process. In attempting to answer this question, reference has been made to government programs in other countries (see chapter IV), as well as a study of some of the domestic effects of U.S. Government actions on a selected group of industries (see chapter 111). There are two general conclusions that can be drawn from these sources. On the one hand, it was found that indirect effects of Government action can be extremely efficient in promoting technological change in specific industries, even when such effects are unintended. On the other hand, as a general rule, direct Government support for technology tends to be more effective in the early stages of development, rather than later when the technology nears commercialization (see issue #2).

The potential effectiveness of the procurement process to stimulate and encourage innovation in the private sector was particularly borne out by the industry studies performed for this report. Indeed, the purchase by the Government of new, innovative products was found to be one of the most efficient stimulants of new technology. That procurement could be used to enhance innovation was recognized by the Commission on Government Procurement, and was embodied in some of the recommendations in their 1972 report to Congress. Many of these recommendations, in turn, have been included in legislation now before Congress.[2] Nevertheless, the recognition is lacking that procurement expenditures may in certain circumstances constitute a more efficient alternative to direct subsidy of R&D.

Another weakness in present policy results from the fact that there is at present no Federal agency charged with the mission of assuring the technological health and vitality of American industry generally. As a result, there is no focus in

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‘For example, the carpet industry’s adoption of synthetic fibers was stimulated by the 1950 ban on the import of Chinese wool. See chapter Ill.

[2]S. 1269 the Federal Acquisition Act,

the Government for the support of general, nonappropriable research related to this broad mission. (The Directorate for Applied Science and Research Applications (ASRA) at NSF may do some of this, but only as a secondary mission for the agency, and on a very small scale.) For example, the Department of Energy supports research in basic nuclear physics, and the Defense Department supports laser research, because these are fields related to the missions of these agencies. However, there are other scientific fields, for example, the study of friction, corrosion, mechanical design, catalysis, manufacturing technology, etc., that are relevant to a wide variety of industrial processes, but for which no agency feels responsible.

Increased Government support for technology basic to commercial development is not likely in the majority of cases to result in patentable inventions; however, in those instances where patents might arise, there is an issue as to who should own the patent rights to inventions stemming from publicly funded R&D. The situation regarding this question is currently quite chaotic. Each of the various mission agencies has, over time, adopted its own procedures in dealing with the issue, and the result is that there is no uniform treatment in the Government either in policy or in its implementation. The effectiveness of patents, either in promoting innovation or in stifling competition and thereby retarding it, differs from industry to industry. However, studies[3] have shown that, in general, patents held by the Government and licensed only on a nonexclusive basis are used much less often than those in the private sector. Of course, there are social goals other than that of promoting innovation, and the granting of a monopoly license to manufacture and market a product developed in part with Federal funds may conflict with these. However, from the restricted viewpoint of this analysis, the conclusion is clear: a policy of refusing exclusive patent rights to federally funded inventions has a retarding rather than a stimulating effect on innovation.

The preceding discussion suggests the following options for possible congressional action.

1. Initiate a policy of selective procurement of products embodying innovative technology at prices that reflect the R&D costs incurred by the innovator. Such purchases of innovative products, by creating a market, may do more to stimulate innovation than would an equivalent expenditure of research funds.

   — This strategy is most likely to succeed in those situations in which a commercial market exists for the product, the technology has matured, and the price has dropped.
   — Procedures for dealing with the problem of monopoly creation-might include parallel funding of several firms, or mandatory licensing by firms that capture a set fraction of the market.[4]

2. Establish a funding capability for the support of advanced, nonappropriable research responsive to a wide variety of societal needs, such as energy conservation,[5] or manufacturing productivity. The research could focus on technical subjects of wide applicability such as product fatigue, safety friction, corrosion, catalysis, etc.

   – A program could be set up either as a separate agency or as a function within an existing agency to monitor and fund nonappropriable research in fields of interest to a wide variety of industries.
   — Macroeconomic analysis suggested in issue #8 would enhance the ability of this program to concentrate on those technologies of interest to specific industrial sectors, and specific manpower and environmental needs.

3 Grant, under appropriate safeguards,[6] exclusive patent rights to inventions made by private individuals or firms under Government funding, as in Europe and Japan.

   — Requiring guarantee of an intention to work the patent.
   — Avoiding the creation of a monopoly, for

[3] See the Government Patent Policy Study performed by Harbridge House for the Federal Council on Science and Technology, May 17, 1968,

[4] See chapter IV for a discussion of Japan's handling of this problem.

[5] The Advanced Technology Assessment Program of the Department of Energy does some of this on a very small scale

[6] Bill HR. 6249, the Uniform Federal Research and Development Utilization Act, addresses the Issue,

example through "march-in rights" by which the Government may revoke exclusive patent rights.

ISSUE 2

Reconsideration of the Role of the National Laboratories

Should Congress consider the appropriate role of the National Laboratories in the support of technological innovation?

The question of the proper use of the federally owned and funded research institutes—in-house laboratories, national centers, and federally funded research and development centers (FFRDCS), which we refer to here as "National Labs''—is becoming a more and more critical issue, both for Congress and for the executive branch, as Government research activity expands into traditionally private domains (e.g. energy) and as the number and influence of the Labs grow commensurately. Indeed the Office of Technology Assessment (OTA), through its R&D Policies and Priorities Program, has been studying this issue, and has issued a draft report (National Laboratories Issues, May 9, 1977), which explores its implications thoroughly.

There is no doubt that the National Laboratories can perform a very useful role in undertaking research of broad social benefit, but which is unlikely to be performed in the private sector. Examples of such research might include work done to demonstrate the feasibility of specific pollution control technology, or investigations of alternative methods for the storage of radioactive waste products.

Nevertheless, there is significant doubt as to the advisability of involving the National Labs in the development of technology of immediate commercial significance because they are not closely attuned to the market. A strong conclusion which emerges from an examination of actual industry responses to governmental initiatives, both here and abroad, is that direct Government funding or performance of R&D is generally unsuccessful in creating commercially useful technology when it is applied to the later usages of the innovative process.

In addition, experience has shown that the problem of "spinning off" a new technology to the private sector at the appropriate stage is a very difficult one. Lastly, involvement of the National Labs in technology of commercial significance creates a bias toward in-house performance because of the competition engendered between them and privately owned research facilities, and the political difficulties sometimes encountered by an agency in locating large programs in specific private firms. The problem of competition can become serious when a National Laboratory serves a dual role as research facility, and as contract monitor or proposal evaluator.

The problems inherent in the competition between Government-owned and private R&D facilities, and their potential for inhibiting innovation, have been recognized by the Office of Management and Budget, [7] and more recently by the OTA study referred to above. The issue has not yet been dealt with effectively by legislation. Appropriate congressional actions might include the following:

1. Develop an explicit set of guidelines for use by the research-funding agencies in deciding which projects to fund in-house and which to support in the private sector on the basis of:

   — Time-horizon of research,
   – Potential for commercial application, and
   – Direct utility to mission of sponsoring agency.

2. Cooperate with the executive branch, to define explicit missions for the various National Labs, in keeping with the overall mission of their sponsoring agencies in order to:

   Clarify goals to facilitate performance evaluation,
   Control mission expansion beyond original boundaries without congressional oversight, and
   — Possibly reduce the scope of National Lab activities so as to eliminate programs that would be more productive in the private sector.

[7] 0MB Circular A-76, as revised, sets forth the genera] Federal policy of relying on the private sector, and lists a number of restrictive circumstances that must apply to justify the Government providing an industrial or commercial product for itself.

3. Cooperate with the executive branch in developing new roles for the National Labs, in performing research of broad social benefit that is unlikely to be undertaken in the private sector.

ISSUE 3

Facilitating New Entrants Into the Market

Should Congress consider measures to facilitate the entry of new firms and inventors into the market as a means of encouraging the introduction of new technologies and innovative entrepreneurship?

Technological innovations are frequently brought to the market by new firms or inventors who translate a new idea into a commercial venture. Similarly, new or small firms often have the flexibility to adapt easily and effectively to new and innovative ideas. It is important therefore that the entry and survival of new firms in the private sector be facilitated.

The relationship between technological change and new ventures may be seen from two perspectives. First, a new firm may be the direct result of a technological innovation by, for example, an individual inventor who decides to bring his new product into commercial use or an individual or group of individuals in an older, more established firm who decide to spinoff a new company founded on a new product. The older enterprise may even decide to create a new firm as a more appropriate vehicle for introducing a new technology.

Second, the characteristic of "smallness" or "newness" in an enterprise may offer the firm greater flexibility in experimenting with new ideas or processes. Production processes are less well-established and capital equipment is frequently more all-purpose. The new firm has no established market image that must be maintained and therefore may be more inclined to assume commercial risks in its effort to gain a market niche. This does not imply that older firms are by nature less capable of innovative activities than the new, smaller firm. Rather, the perceptions of risk and long-term gain may be different at the margin, with the small entrepreneur more willing to act on a new idea or product, which will differentiate him from larger, more powerful producers.

Ease of entry of new firms in the free enterprise system is an obvious economic as well as social objective in the United States. The ability of firms to enter and leave a market is a critical feature of an economic system with a sound competitive environment. This report emphasizes another dimension to this picture, i.e. , that there is a strong technological objective as well in policies to assist the entry of new firms. New technologies with the potential of significant commercial use should not be kept from the market by unjustified structural, financial, or legal barriers. Yet the authors believe that the current U.S. industrial and financial structure does—even if inadvertently—impede easy entry of many potential new firms. Several examples of types of barriers that might be expected to face would-be entrants are:

Venture Capital Restrictions

The new entrepreneur frequently requires outside capital to launch his operation. This must be obtained through the private or public market. The Securities and Exchange Commission regulations (particularly Regulation #144), with respect to private placements of venture capital, limit the rate at which investors can recoup their investments. In short, the investors in these new firms are unable to obtain a fast payback. Entry into the public market poses extremely difficult problems also. For the new or small firm to go public, intensive preparations are necessary, involving high costs associated with registration of public issues. Furthermore, the entrepreneur bears a greater liability compared to the investor when entering the public market.

Tax Disadvantages

Although certain tax provisions have been designed to assist new entrants or small firms (such as Small Business Investment Companies (SBIC) and subchapter S of the IRS code), the new firm nevertheless encounters a variety of obstacles. For example, capital gains are treated less favorably than formerly, e.g., the increased holding periods and changed stock option provi-

sion. This is keenly felt by the small entrepreneur in need of investment capital. The new tax provisions reduce investor interest in investing in smaller, riskier firms. As investors themselves find such firms less interesting, the potential entrepreneur, having difficulty in selling his shares to the public, may be frequently induced to merge with older larger firms to avoid capital-gains taxes and obtain dividend payments.

Other provisions affecting the capital position of the new firm, compared to the older firm, are the loss carry-forward and carry-back rules. Existing firms can carry back losses, an advantage that is clearly impossible for new firms. Hence the older firm enjoys a financial advantage over new firms in introducing an innovation that does not bear immediate profits.

Regulatory Barriers

New firms may have greater difficulty in meeting environmental and health regulations than established firms, which are already structured to comply with such regulations. They may lack adequate managerial or technical skills to meet Government requirements. (Issue #4 proposes programs to deal with this problem.) Also, the total cost of compliance may be prohibitive for new or small firms, either discouraging their formation or inducing them to sell out or merge with larger firms.

Market Barriers

New entrepreneurs typically face greater market uncertainties. For example, established technologically advanced firms frequently benefit from substantial Government procurement. New firms with only a short track record may have little chance for Government contracts. Furthermore, the market power of existing firms bears heavily on the new small entrant. This power frequently results in their absorption through merger or acquisition or through product imitation by larger firms with well-organized marketing systems.

While solutions to these special problems are not always obvious and often run awry of other policy considerations, Congress should study measures to ease the problem of entry for new firms as well as to improv~ chances for survival against stronger, more established firms. Several alternative actions might be:

1. Early venture capital assistance (such as the National Research Development Corporation (NRDC) in Great Britain).
2. Industry-Government joint-venture arrangements.
3. Selective use of Government procurement to assist new technologically innovative firms. (Studies of the electronics industry have shown that Government procurement was an important factor in the early health of the industry.)
4. Stricter antitrust enforcement to strengthen the position of the new firm from the market domination of larger firms.
5. Consulting assistance to new firms in meeting regulatory requirements. (See issue #4 “Diffusion of Technology.”)
6. More favorable tax treatment for new firms (e.g., higher carry-forward provision, changed depreciation, lower tax on capital gains).
7. Simplification of task of obtaining information about and using various Federal, State, and local incentives in form of cutoff rules in application procedures for small firms, and computer data-bank information sources on available aids.
8. Patent protection for small firms and inventors against violations and encroachments from larger firms, such as through use of a national patent board where violations can be reported and prosecuted where necessary.

ISSUE 4
Diffusion of Technology[a] Within the Private Sector

Should Congress consider comprehensive programs to enhance the dif - fusion of existing technologies and technical information within the private sector?

[a]Diffusion of technology from Government sources to the civilian sector is discussed in issue #1, and international transfers in issue #8,

Diffusion means the spreading of technology and technical information to new users. As opposed to generating new technologies, diffusion of existing technologies is usually a low-cost way to bring about greater economic benefits by: (1) raising productivity levels of industries by closing technology gaps, (2) encouraging more innovations by helping small- and medium-size firms compete with larger ones, and (3) promoting new uses of technology by means of transfers between different industries.

Many industries are characterized by a few, large technology leaders and many smaller producers. For the U.S. economy more than 95 percent of all manufacturing establishments employ less than 200 people. ' Although there are other factors besides diffusion barriers which result in wide ranges of technology in terms of age and productivity being adopted by producers of similar products, there exist many opportunities where better diffusion can help close the gap between best-practice technology and average technology. A General Accounting Office (GAO) study of manufacturing productivity[10] suggests that wider diffusion of modern manufacturing technology can improve industrial productivity, especially among small batch-process manufacturers, which contribute 36 percent of manufacturing's share of the GNP. The study maintains that such productivity improvement can in turn increase the competitiveness of U.S. products, decrease the cost of Government purchases, and reduce inflationary pressure.

Technology gaps tend to stifle competition and reduce the incentive for large firms to innovate. By promoting diffusion of technology, the Government can help small- and medium-size firms compete more equally with larger ones, and also help foster more innovations. In the special cases of pollution control, health, and safety standards, the Government can help the diffusion of technologies for meeting these requirements and achieve wider compliance by helping small firms, which tend to lack the knowledge of regulatory requirements and the means to comply. [11]

'U.S. Statistical *Abstract, 1976* (Department of Commerce, Bureau of Census).

[10]*GAO Report to the* Congress, Manufacturing Technology – A Changing *Challenge to improved Productivity, LCD-75-436,* Washington, D.C, June 1976.

[11]Charleswater Associates, Inc., *The impact* on *Small Business* Concerns *of Government Regulations That* Force *Technological Change,* Report to SBA and NBS, September 1975,

The diffusion of technology used in one type of application to another can often result in new products, sometimes new industries. The use of sophisticated electronics in watches is perhaps an example. Thus wider diffusion of existing technologies not only increases opportunities to improve technology, but can also lead to more innovations. This is supported by the findings of the industry study in this report (see chapter III).

The funding of R&D to generate new technologies has often received much more attention than the diffusion of existing technologies to new users. Since diffusion is an important mechanism in raising average productivity levels of industries and in spreading the benefits of technological innovations to bigger segments of the economy, the problems of diffusion of technology in the private sector deserve Government attention.

The structure of the marketplace frequently works against the diffusion process. Many industries are dominated by a few, large technology leaders, which are obviously reluctant to help diffuse technology to their smaller, less efficient competitors. Such oligopolistic firms often use patent and patent-pooling practices to reinforce the diffusion barrier. By themselves, small firms often lack information and other resources to take advantage of more productive available technologies.

Given the lack of market forces to promote diffusion, there are few Government programs aimed at redressing the situation. The GAO study mentions some efforts by the Small Business Administration (SBA), National Technical Information Service (NTIS), and others, but maintains that such efforts are fragmented and very limited. In contrast, it points out that Western Europe and Japan have well-developed government-directed programs for overcoming barriers to diffusion. These include widespread regional productivity centers and various government-industry-university cooperative efforts.

To address the diffusion problem, a comprehensive policy might use a variety of instruments:

1. Establish a nationwide network of local centers, that provide small firms with technical, informational, and consultative assist-

[12]A model of this kind of program, entitled State Technical Services, was enacted in the mid- 1960's (22 U.S. C. 278). A residue of the program still exists in 23 States.

ance about the availability and use of technologies applicable to their needs through such means as:

— Technical agents that provide advice and assistance to firms on request and act as interface between firms and various sources of Government assistance such as NTIS, National Bureau of Standards (NBS), etc.;
— Seminars and workshops on technological problems/solutions for small firms in specific industries;
— Legal/administrative/technical assistance to meet Government regulations such as pollution, health, and requirements (e.g. Occupational Safety and Health Administration consultation program); and
— Financial assistance through loans, guarantees, or tax provisions for investments in regulatory compliance equipment and facilities (e.g. Environmental Protection Agency/Occupational Safety and Health Administration/Small Business Administration financial assistance for pollution control).

2. Support and encourage industry cooperative activities by small firms (within the limitations of antitrust legislation) through industry trade associations, professional associations, or marketing and purchasing cooperatives to:

— Conduct adaptive R&D and demonstration projects of existing technologies for small-firm applications;
– Construct jointly-operated production and pollution control facilities;
– Purchase materials and services on a cooperative basis;
— Articulate joint technical problems and needs; and
– Promote group efforts of self-help.

3. Support for technology information/communications systems that serve both technology suppliers and users such as:

Government-operated systems such as NTIS; and
— Private technology brokerage firms.

4 Require compulsory licensing to competitors when firms attain certain market-shares (see Japanese practice in chapter IV).

5. Support for programs where the Government purchases technology and resells it to multiple users (see Preproduction Order Support Program of Great Britain, in chapter IV).

ISSUE 5
Implementation of Environmental and Safety Regulations

Should Congress consider new means of implementing environmental and safety regulatory requirements which will encourage the development of innovative compliance technologies and safer products and materials?

Much of the debate concerning environmental regulation to date has focused on the need for new legislation and the stringency of regulatory requirements. Questions relating to implementation of the legislative mandates have been underemphasized. In particular, the role of technology vis-a-vis regulation has largely been ignored. The suggestion here is that increased policy consideration be given by Congress to issues concerning regulatory system design and implementation so as to encourage both the development of the new technologies necessary to achieve environmental goals and the development of safer products and materials.

There are at least two important aspects to the relationship between regulation and technological innovation. One concerns how regulation affects or is likely to affect innovation, and the other concerns the role of technological innovation in achieving regulatory goals. As to the first aspect, there has not been a great deal of systematic research about the effect of environmental regulation on U.S. technology[13] and the issue re -

[13] There have been several studies of the pharmaceutical industry, notably those of Peltzman *(Journal of Political* Economy, Vol. 81, September/October 1973), Warden and Lasagna *(Regulation* and Drug *Development,* American Enterprise Institute, 1975), and Grabowski *(Drug* Regulation and Innovation, AEI, 1976). Other industries studies include automobiles (see Abernathy and chakravarthy, op. cit., p. 47) and an ongoing CPA study of the chemical industry.

mains controversial. From the evidence which does exist, one can say with certainty that it is impossible to make simple or general characterizations about the nature of the impact. At a minimum, it is necessary to distinguish between the direct effects on innovation in compliance efforts and the longer term, ancillary impacts on the general process of innovation. The effects in both instances are likely to vary significantly depending on the nature of the regulation and the regulated industry.

The effects of regulation can be positive or negative. For example, positive effects may often occur when regulatory requirements complement some existing market force (for example, in the case of fuel economy regulations on the auto industry—chapter III, p. 00) or where a new or ignored area of development can be exploited. Regulatory constraints, however, may hamper innovation by blocking certain new technical options or by decreasing the resources available for new product development. Of particular concern is the fact the regulation may hurt the competitive position of small firms. As these effects can only be understood on a sector-specific basis there is **a** need for such analyses concerning the impact of regulatory programs as an input to regulatory design (see issue #8 for further discusson of analysis needs).

Although the basic environmental requirements in the United States have been highly progressive (viewed internationally), mandatory standards have been the almost exclusive means used to achieve them. Some consideration has been given to the "technology-forcing" character of health-based regulatory standards, [15] but in general, the encouragement of new technologies has been absent as a conscious element of regulatory policy. This has not always been the case abroad, where several different approaches to regulatory design, which focus specifically on new technology, have been implemented.

[14] In addition to chapter III, see U.S. Department of Commerce, The *Effects of Pollution Abatement on International Trade – II.III.IV* (published yearly). which finds little or no effect *on the* U S. trade position; 1. Waker (ed.) *Studies in* International *Environmental Economics,* Wiley & Sons, New York, 1976, a series of essays; and Charleswater Associates, *The* impact *on* Small *Business Concerns of Government Regulations That* Force *Technological Change,* Boston. 1975.

"See "Technology-Forcing and Federal Environmental Protection Standards, " *Iowa* L Reu , February 1977.

The foreign experience is but one source from which new means of implementing regulations and facilitating regulatory compliance can be uncovered. A systematic effort to improve the design of regulations might include the following two components:

1. Evaluation, through such means as a task force, special commission, or research effort, of the means by which innovative compliance with regulatory needs can be achieved; "[b] and
2. Application in appropriate regulatory contexts of demonstrations, experiments, or new policies designed to facilitate the achievement of regulatory goals through the encouragement of technological change. [17]

Either component would require congressional direction. Some of the particular regulatory alternatives, which might be either studied or implemented, are contained in the following list. It is not suggested that any of these alternatives be immediately adopted. Rather, they are offered as examples of possible new methods of regulating and serve to illustrate the need for a thoroughgoing reassessment of the means by which to achieve regulatory goals via technological innovation.

1 Expansion of direct Government support for in-firm technological development in crucial areas (e. g., pollution control in automobiles) leading to both process and product change.

2 Modification of pollution control tax incentives, i.e., accelerated depreciation and municipal bond financing, so as to favor process redesign and the development of new products and materials rather that add-

"The regulatory reform efforts of the Ford and Carter administrations are not what is envisioned here. These efforts have not concentrated on the utilization of technology but rather on an efficient regulatory process and the economic impacts of regulation.

"The ETIP Program in the Department of Commerce has as one of its components this purpose; however, it is a small effort.

on modifications associated with purchasing of pollution abatement equipment. [18]

3. Government financial support for major new technological advances when firms are unlikely to undertake them on their own either because such development would require large-scale efforts, would be long in coming to fruition, or their results non-appropriable (e.g. closed systems to contain toxic chemicals). This occurs in Germany and France as part of broader programs to encourage the development of new technologies for various social purposes.

4. Greater industry-specificity in standard setting (e.g. in the OSHA context) so as to minimize hardship when new technologies would be difficult to develop and to maximize health safety protection when the technological capacity is great.

5. Alternatives or supplements to standard setting, such as products liability or strict liability imposed on polluters, as in Japan.

6. A formal antitrust exemption procedure to clarify the status of joint R&D relating to environmental control technology.

7. Special programs to assist small firms' compliance efforts (see issue #3).

8. Effluent taxes as a means of achieving water pollution abatement on a regional basis (these have apparently been successful in Europe, especially in Germany, and are alleged to provide continuing incentives for more efficient control technology) .20

'"These provisions, Section 169 and 103 of the Internal Revenue Code, have been criticized as 1) ineffective, because the general investment tax credit is often more generous, 2) effectively available only to the large firms that can undertake municipal bond financing, and 3) penalizing radical improvements by their exclusion of "significant" (i. e., more than 5 percent) process change.

"The Japanese force polluters to compensate all victims of pollution via a system similar to workers' compensation. A bill to enact such a mechanism in the United States, H.R. 9616, was introduced in this session of Congress.

[20]Effluent taxes are widely endorsed by economists (see R. Solow, "The Economist's Approach to Pollution and Its Control, " *Science*, Aug. 6, 1971). They are opposed by many others on a variety of grounds (see M. Weitzman, "Prices vs. Quantities, " Review of *Economic Studies*, October 1974), especially where life-threatening hazards are involved.

ISSUE 6
Manpower Resources, the Labor Market, and Technology

Should Congress consider an integrated national manpower policy designed (a) to strengthen the contribution that qualified manpower can make to the innovation process and (b) to alleviate the disruptive impacts that rapid technological change can have on employment?

The interaction of labor and innovation is complex and frequently misunderstood. There is little disagreement over the key role that highly qualified manpower resources play in the innovation process. The existence of qualified technical personnel at all levels is critical to the environment for innovation. Most technologically advanced foreign countries place heavy emphasis on manpower policies as a key contribution to the capacity of industry and the research establishment to undertake technological change. The essence of these manpower policies is to prepare human resources for future needs of industries and the economy in general. As such, there is an element of long-term planning based on judgments about the nature of future needs.

While the importance of labor for technological change is clear, technological change itself has an impact on labor. As technological innovation raises demands for qualified personnel at one end of the spectrum, the effects of such innovation may cause a shift in demand for skills on the other end. Technological change in industries frequently leads to changes in the "skill-mix" which their production process requires. Certain worker skills may become obsolete and the result may be layoffs and serious dislocation.

The labor market issue therefore takes on a double dimension. Beyond the need for personnel in the technological innovation process, another basic issue is how to adapt a supply resource—manpower—to rapidly changing demand. Technological change in particular may lead to a shift in the demand curve for labor rather than a simple decline along the demand curve. This shift may cause a change in the demand for skills as opposed to the numbers of workers.

In general, the overall macroeconomic effect of technological innovation on employment levels is considered to be positive insofar as technological progress continually produces new products, processes, and services leading to new employment opportunities. 21 Technological innovation is a key element of a company's competitive position in domestic markets and of U.S. firms in general in international markets. Indeed, it can be argued that the failure of a company or sector to stay abreast of technological developments may over time lead to declines in employment as a result of the declining fortunes of the firm or sector. In this broader sense, therefore, labor has a genuine stake in the technological health of individual sectors and firms.

However, while the macro impact of innovation may be favorable for the employment picture over time, the micro effects of technological change may frequently result in serious labor dislocations. Manpower policy is therefore confronted with the problem of how to treat such disruptive impacts on the labor force that result from such changes at the level of the firm.

The United States today (as illustrated in program area IX in chapter 111) has no conscious manpower policy specifically designed to strengthen the environment for technological innovation and to respond to the needs of workers in a technologically changing economy. In particular:

- There is no central body mandated to study and predict the impacts of technical change on the labor market.
- There exists no general labor adjustment assistance program (a) to assist workers financially to make the difficult transition from one job to another and (b) to offer workers retraining opportunities in skills that industry is currently in need of. The only current program deals with workers in industries "injured by excessive foreign imports. "
- There is no longer term strategy, based on future projections, for educating middle- and higher-level technical personnel needed to sustain the process of technological innovation. 22

Both short-term measures and longer term strategies are needed to meet these related objectives. Adaptive and continual training of manpower resources are required to provide labor with the mobility to adjust readily to changing skill requirements and to furnish the vital human inputs to the process of technological change.

The following outline suggests alternative measures for congressional consideration:

1. Manpower Forecasting and Planning—to prepare basis for labor adjustment assistance and long-term technical education strategy:
   - Early-warning systems in various sectors to predict areas of foreseeable labor shortages and surpluses; and
   - Mechanisms for translating the above data into policy planning options for educational strategy and labor adjustment assistance.

2. Labor Adjustment Assistance–short- and medium-term measures to assist displaced workers:
   - Financial assistance to aid worker transition from job to job;
   - Adequate financial aids to workers to undertake retraining for new jobs:
   - Incentives to firms to retain and retrain their own personnel for new positions (as in Japan) or payroll taxes on employers to finance worker retraining (as conducted in France);
   - University-industry cooperation for retraining of higher level personnel in industry for new responsibilities;
   - Publicly financed continuing education centers for displaced workers according to sector or industry;
   - Improved employment information and placement services according to sector or industry to assist in rapid relocation of workers.

"Lowell Gallaway, "Labor Mobility, Resource Allocation, and Structural Unemployment, " *American Economic Review*, LM No. 4 (September 1963); Otto Eckstein, "Aggregate Demand and the Current Unemployment Problem, " in *Unemployment and the American Economy,* ed., A M. Ross (New York: John Wiley& Sons, 1964),

[22]It should be noted that there is also nothing in the United States approaching the European movement toward codetermination that would guarantee labor a voice in management decisions concerning technology,

3. Long-Term Technical Education Strategy—to improve the environment for technological innovation:

   — Establishment of training institution network to prepare middle-level technical personnel;
   — Raising the professional stature and increasing financial rewards for teaching personnel in technical institutes;
   — Mandatory continuing education in certain key technical fields (e.g. where licenses required);
   — University-trade school-industry cooperation for upgrading and updating scientific and technical personnel; and
   — Incentives to industry for in-house traineeships for qualified personnel (as practiced in Germany for example).

ISSUE 7

International Commerce and Domestic Innovation

Should Congress consider a comprehensive program to strengthen the U.S. position in international trade by enhancing the technological competitiveness of U.S. industries adversely affected by international commerce, and assisting labor and business to adjust structurally when dislocations occur?

International commerce (trade and technology transfer) has important implications for domestic innovation. First, technological innovation is a major determinant of competitiveness in international trade .[23] Competition with foreign producers in international markets as well as in the United States increases the need for U.S. producers to innovate. Second, access to foreign markets provides an extra stimulus to U.S. innovations by increasing the demand for U.S. goods and technology. Third, proceeds from foreign sales of U.S. corporations help finance their R&D. It is estimated that the foreign sales of U.S. corporations (after consolidating their exports from the United States and overseas sales of their foreign subsidiaries) accounted for almost one-third of their total sales in 1976.[24] Fourth, technology transfer from abroad has stimulated or complemented many U.S. innovations. To cite a few examples, continuous casting and the basic oxygen furnace in steelmaking, the jet engine, float glass manufacturing, and penicillin were all first introduced abroad and then brought to the United States.

While many benefits for the U.S. economy and for domestic innovation derive from internation commerce, there are clearly problems for some U.S. industries also. Competition with foreign producers, whether here or abroad, is a dynamic process that creates a changing mix of opportunities and problems for U.S. industries as comparative technological advantages shift over time. Coupled with other changing international conditions, this has caused domestic job losses in some sectors, or is threatening to do so, through rising imports or declining exports.

Consumer electronics, steel, textiles, and shoes are examples of industries severely undercut by imports and where domestic jobs have been lost by the closing of plants in the United States. In these sectors, there is strong labor and business sentiment in favor of restricting imports. In other manufacturing sectors, labor groups have voiced forceful complaints against the export of jobs by U.S. companies transferring technology and making direct investments in foreign countries. Although some have argued that these actions by U.S. businesses are defensive in nature and in response to changing international conditions and some have even argued that there are net gains in U.S. jobs as a result of U.S. direct investments overseas, [22] there are undeniable job losses for specific workers.

Although in the modern world of increasingly interdependent economies international commerce is essential to national welfare, it results in costs as well as benefits. Because of these costs, there is mounting pressure on the U.S. Government to institute protectionist measures. How-

[23] See, for example, Raymond Vernon (cd.), *The Technology Factor in International Trade* (National Bureau of Economic Research, New York, 1970).

[24] Based on sample of 295 U.S. companies with a combined total sales of $588 billion, as reported in "Foreign Sales Special Report, " *Standard and Poor's industry Surveys*, July 28, 1977.

[22] See, for example, several studies summarized in Robert Hawkins, *Job Displacement and the Multination Firm –A Methodological Review*, Center for Multinational Studies, Occasional Paper No. 3, Washington, D. C., June 1972.

ever, protectionist measures alone are unsatisfactory and dangerous without accompanying actions to remedy basic structural weaknesses. Protectionist measures tend to generate inflationary pressures domestically and invite international retaliation against U.S. exports, both of which will cause more job losses. They merely alleviate symptoms and reinforce long-term rigidities in industrial structures, while denying U.S. consumers cheaper or better products. While short-term protectionist measures may be necessary in some cases, they should be accompanied by a comprehensive package of technological/structural adjustment programs that can soften the dislocations caused by declining industries, help revive their competitiveness, or assist in their transformation.

Although there are programs in existence for labor and business adjustment administered by the Departments of Commerce and Labor and the International Trade Commission, they are inadequate and fragmented for this purpose. An integrated policy towards technological/structural adjustment might include the following components:

1. An early-warning system based perhaps on the kind of sector-specific microanalysis (see issue #6) that would yield forewarnings about declining industries and their problems and thus avoid crisis-triggered reactions (e.g. the recent case of steel). This system should be part of a policy-formulating unit that will coordinate relief and adjustment assistance decisionmaking.
2. A comprehensive labor adjustment program that can help labor adjust, retrain, or relocate (see issue #4).
3. A comprehensive business adjustment program which may include:
   - Short-term protectionist support under special circumstances (e. g., for vital or infant industries);
   - Capital support for modernization and restructuring (e. g., R&D funds, exemption from antitrust of joint R&D by industry);
   - Regulatory support (relaxation or exemption of regulatory measures that impact on industry, e.g., in a recent case, water pollution standards were relaxed for parts of the steel industry); and
   - Export support (e.g., use of Export Imeport Bank (EXIM) bank facilities or tax provisions similar to the Domestic International Sales Corporation (DISC) to promote industry exports).
4. An R&D support system that enhances the technological competitiveness of U.S. industries by supporting:
   - Technological development based on assessments of U.S. comparative advantages (see issue #8, sector-specific microanalysis);
   - Technological development that can raise industrial productivity across many sectors (see issue #1);
   - Technological development that can lead to new industries or markets (both domestic and export); and
   - Adaptation and improvement of advanced foreign technologies by domestic industries.
5. Selective use of incentives/disincentives to inflows of technology through the channels of trade, contractual arrangements, and direct investment (as Japan did in the 1950's and 1960's through the Ministry of International Trade and Industry).
6. Selective removal of barriers to technolocw transfer from abroad, e.g., bias against foreign testing data under Food and Drug Administration regulations on introduction of new drugs (see program area XI, chapter 111, for other tariff and nontariff barriers).

ISSUE 8

Support for Sector-Specific Microanalysis

Should Congress consider support for systematic and ongoing analyses of the social, economic, and technological issues pertaining to individual industrial sectors as an input to public decisionmaking?

The overall purpose of this report has been to understand the relationship between technological innovation and Government action. One of the major premises underlying its execution is

that this relationship can best be understood on a sector-specific basis. This **was** a major reason for undertaking a series of industry studies (see chapter III). As the work progressed, however, it became increasingly apparent that there are serious deficiencies in the knowledge base:

- On the industry side, there were often major gaps in the literature concerning the technology-related problems of the sector, such as obsolescence, capital needs, position in international trade, etc.
- On the Government program side there existed an even greater lack of evidence about the effects of various programs and serious deficiencies in the knowledge base upon which to make regulatory decisions.

These deficiencies arise in part from the fact that there is no sector-specific microanalytical capability of significant size in Government today. For example, the Domestic and International Business Administration, part of the Department of Commerce, has concentrated more on macroeconomic data than on sector studies. The National Science Foundation has funded some studies and the National Bureau of Standards also has some capability along these lines, but each is a very small effort. Regulatory agencies also sometime fund such studies in response to a crisis. While these studies may fulfill an immediate regulatory need, they are generally not readily applicable to other governmental needs. Although existing studies performed in firms might provide some useful information, they are often proprietary and not designed to suit governmental purposes.

Accordingly, there is a need for an expanded, Government-supported capability. Most Government actions which significantly affect the technology of an industry must be taken on a sector-specific basis. For example, air and water pollution control standards are, almost without exception, different according to the sector affected. This is a natural consequence of the difference in hazards present and the different technological and economic capabilities of the relevant sectors. Energy conservation regulations are another example of a Government function that cannot proceed without sector-specific disaggregation. Concerns relating to export and import controls, productivity, and employment also require detailed microanalysis for Government decisionmaking.

One example of a study that might be undertaken concerns the steel industry, whose health is currently a subject of major national controversy because of its position in international trade and its ability to comply with environmental regulations. Good thorough studies of the technological position of the U.S. steel industry will be needed in order to develop and implement new policies toward it. Another example might focus on the effect of international trade and foreign direct investment by U.S. multinationals on domestic employment. Because most existing studies only examine net aggregate employment impacts and provide no information as to where the employment gains and losses in fact occur, policies to provide structural adjustment are severely hampered.

Other research needs might include analysis of the capital investment needs in specific sectors, the impact of regulation on technology in selected industries, or the effectiveness of existing Government programs on a sector-specific basis.

There are several institutional alternatives possible to support such analysis including:

1. Government financial support for sector analyses performed in universities or research institutes;
2. Support for industry-performed analyses; and
3. Performance of the analyses in one or more Government agencies.

Irrespective of the institutional arrangement, the analysis could be oriented either toward (1) broad policy areas such as control of international trade, but with particular reference to individual sectors or (2) specific sectors, such as steel, for use in a variety of policy contexts. In either event, the analysis would be useful to the formulation of public policy in regulation, planning, establishing research priorities, etc; and could aid private decisionmaking as well by providing a data base and new syntheses of existing information.

ISSUE 9

Support for Hazard Analysis

Should Congress consider supporting additional national capability for anticipating significant hazards arising from new and existing technologies?

Recognition and control of significant hazards before they create damage is obviously a desirable goal. Several existing regulatory systems attempt to fulfill this purpose with regard to new chemical products or uses (e.g. pharmaceutical, pesticide, and toxic substance regulation—see policy area 11 for this listing). In addition, assessments that may have hazard identification and analysis as a component are performed by various agencies (e. g., the environmental impact statement process required for major Federal actions, OTA studies, etc. —see program area I, chapter 111).

While each individual program has its own virtues and drawbacks, the overall effort may lack suffient purpose, coordination, and capability to respond to the national need for hazard recognition and prevention, especially with regard to hazards already in the marketplace or environment. There are several reasons for this.

First, is the existing programs coordination .2' For example, although the dangers of a toxic substance in the workplace may be recognized, its control as a hazard in the atmosphere or in a consumer product is often not coordinated with the workplace regulatory effort. This may result in transfer of the hazard from one location to another (for example by ventilation from a factory into the atmosphere) rather than effective control.

Second, hazard analysis is not contained within the mission of many agencies. For example, the National Aeronautics and Space Administration and the Department of Defense had the capability but not the responsibility to be concerned about satellite radioactivity before the recent Canadian incident involving the crash of a Soviet satellite. Moreover, the hazard analysis function that does exist is typically only incidental to the larger agency mission. For example, EPA's pesticide division attempts to prescribe labels, register pesticides, prescribe standards for licensing applicators, as well as to prevent "unreasonable adverse effects" on the environment.

Third, hazard analysis is a relatively new discipline and has so far achieved little recognition or support. Consequently, its analytical techniques are as yet underdeveloped.

For all these reasons, hazards typically go unrecognized until a crisis develops. The record of the environmental/safety movement is replete with examples in this regard: vinyl chloride, recombinant DNA, and most recently, radioactive debris from a Soviet satellite.

Several alternative policies may be undertaken to expand and improve the existing hazard analysis capability, including:

1 A central hazard identification/analysis mission and capability located in a Government agency, for example OTA *or* EPA. This agency could either conduct or coordinate hazard analysis efforts in Government.

2. Government financial support for hazard analysis performed elsewhere (for example, through NSF).

3. Government support for training and research to develop a hazard analysis capability, for example, through curriculum development, support for students, publications, etc.

4 Hazard identification and analysis in firms—although this is occuring already to some extent **as** a result of regulatory and legal (e.g. products liability) requirements, new, more formal requirements could be imposed.

5 Education of workers and consumers in hazard identification.

6. Systematic and ongoing monitoring of environmental and health research in the United States and abroad to keep abreast of new developments.

7. Adequate followup analyses or procedures to ensure that hazards identified are controlled to the extend feasible and to monitor the analysis capability.

"The recent voluntary cooperative effort in the toxics area by OSHA, EPA, CPSC. and FDA is an encouraging initial step at meeting this problem.

Whatever the mechanism, its existence may be as important as its form. Although hazard identification/analysis can be a systematic, scientific undertaking, it is also undeniable that it may involve a good deal of serendipity. Therefore, a consciousness about the problem and a mission to be concerned with it may be as important as the development of new analytical techniques.

ISSUE 10

Affecting the Demand for New Technologies.

Should Congress consider increased use of programs of policies that focus on the demand for new technologies rather than on supply?

Most Federal programs intended to affect technological innovation have historically been concerned with the supply of new technologies. Accordingly, they have attempted to increase this supply by, for example, reducing the cost of development, undertaking research in publicly supported laboratories, increasing the rewards for innovation, etc. (See program areas IV through VIII in chapter III.) This policy emphasis has resulted in part from a widely held, but overly simple, view of the innovation process, which sees R&D as the overridingly important aspect. In contrast, recent research emphasizes the complex interconnectedness of various stages in the innovation process and recognizes that market demands are often a more important motivator of innovation than technical discoveries.

Experience suggests that policies which work through influences on demand may often be more effective than those which concentrate on increasing supply. One way of influencing demand is by Government procurement. Evidence presented earlier in this report shows that an assured Government market for new products can be an effective stimulus to innovation. This conclusion is also strongly supported by the foreign experience. Another way of influencing demand is to impose a Government requirement. Environmental regulation, for example, had fostered innovation by creating a demand for safer, nonpolluting technologies. Both of these examples show programs that create new or expanded markets.

Most of the factors that mold consumer demand for new technologies arise from the private market. Advertising, marketing techniques, and various other kinds of market information play a predominant role in this regard. Although advertising regulation has long existed, it has, until recently, been limited in scope; however, new Government initiatives are likely to influence consumer demand more directly. For example, recent developments in counter, corrective, and comparative advertising attempt to ensure a balance of viewpoints in the commercial marketplace.

Other existing programs also affect demand. For example, product safety regulation may effectively shift consumer demand toward a preference for safe technologies embodied in consumer products. Although such shifts may in fact occur, they are largely unintended from the viewpoint of the regulators, whose major interest is to remove unsafe products from the market, and only incidentally to promote the development of new, safe technologies. (These and other policies are identified in program area XII.)

The potential importance of policies intended to affect demand may be illustrated in the development of energy conservation technology. Decreases in demand (through conservation) and shifts in the nature of demand (through a preference for energy-efficient or nonconsumption alternatives) are both required for conservation to be successful. In order to achieve these two goals, major changes may be required in existing products, production processes, and individual lifestyles. If this is indeed the case, Government action may be necessary to (1) inform consumers fully about the means and benefits of energy conservation, (2) persuade them to adopt different consumption patterns, and (3) counteract or control existing advertising practices inimical to energy conservation .27 Moreover, the Government could vastly increase the demand for energy-efficient technologies by subsidizing their users, for example, through a tax credit for solar heating or low-interest home insulation loans. Similarly, Government purchase of such products could speed their development and commercialization.

"AS an example of this third option, France has recently instituted a major program to prohibit any advertising that encourages energy consumption.

Energy conservation is but one example of the areas in which Government can affect technological change through influences on demand rather than by encouraging supply. It is used as an example not to advocate any specific program, but rather to illustrate how the Government can work through demand-side policies in a variety of ways.

The existing imbalance between supply and demand-based policies in the overall Government approach toward technological innovation strongly suggests that consideration should be given to increased use of programs focusing on demand. Such programs might include the following components:

1. Greater emphasis on mechanisms that create new or expanded markets for certain types of technology, for example:

   —procurement,
   —user subsidy,
   —products liability, and
   —regulation.

2. Greater emphasis on mechanisms that directly influence the nature of consumer demand, for example:

   —counteradvertising,
   —consumer information provision, and
   —education.