Promoting Technology/ Industry Developments 5

If innovation or commercial activity are lacking in an area that is important for the public, the government can promote such activities itself. For example, the government might: 1) provide tax-related incentives to stimulate private sector activity; 2) provide private sector grants and loans; 3) stimulate the market by leveraging government procurement powers; and 4) directly fund, develop, and/or provide needed technologies and technology-related services.

Although government has always played a role in promoting technology development. its actions have sometimes been controversial. Conflicts surrounding government promotion of technology and economic development are as old as the Republic itself, providing fuel to fire the political debates between the Jeffersonians and Hamiltonians and the Jacksonians and the Whigs for almost 100 years.[1] Avoiding such controversy for the most part, the government has generally reserved the role of technology promoter to one of last resort. It has assumed a major role only when—as required in basic research, defense, and mission-oriented objectives such as space exploration—it was clear that the

Policies promoting information networks will need to reflect a greater understanding of, and appreciation for, the complex and iterative nature of both diffusion and innovation processes.

[1] Jeffersonians and Jacksonians, for example, rejected plans put forward by Secretary of the Treasury, Alexander Hamilton, to build a national banking system and other infrastructure believing that it would favor the gentry class. Later they opposed national development plans put forward by Whig party leader, Henry Clay, Speaker of the House. Clay wanted to construct national roads and canals and, ultimately, national railroads as well. Jefferson and Jackson, in denying these initiatives, encouraged state and local governments to undet-take this development; thus state and local governments assumed the critical role. See Don Hadwiger, "A History of Rural Economic Development and Telecommunications Policy,"" contractor paper prepared for the Office of Technology Assessment, January 1990, p. 7.

private sector would not do so.[2] Even when providing the funding and setting the research priorities, the government has generally delegated the task of actually performing the work to private sector organizations.[3]

Today, the federal government invests more than $70 billion in research and development. This investment is comparable to, and sometimes higher than, the amounts spent by other countries.[4] Most other governments, however, conduct R&D to achieve commercial goals; in the United States, approximately two-thirds of all government-sponsored R&D is for military purposes.[5] In a knowledge-based, global economy, this difference in emphasis may greatly disadvantage the United States. As a result, efforts are now underway to shift the R&D orientation from defense to economic growth and competitiveness, from basic to applied research, and from public to private sector involvement.[6]

Moving toward more commercially oriented R&D will present a number of challenges, however.[7] Better criteria will be required for determining why some technologies merit greater support than others.[8] Decisions must also be made about the appropriate amounts of funding and how funds can be most effectively deployed. These questions will likely be difficult to answer because the relationships between R&D, technology diffusion, and innovation are not well understood.[9] More often than not, choices about the type and amount

2 Road-building is an example. During President Truman's Administration, road-building failed to keep paCe with increased road use. There was no consensus about the federal role. Rural Senators Milton Young (ND) and John Stennis (MS) sponsored increases inroad appropriations, including $100 million for farm highways. However, at the same time, the U.S. Chamber of Commerce opposed farm highways, characterizing them as "national socialism." President Truman cutback on road construction during the Korean War, even as road use was sharply rising. It was only after President Eisenhower justified federal support for highway construction on national defense grounds that a federal road-building program really took off. See Mark H. Rose, *Interstate Express Highway Politics, 1941-1956* (Lawrence, KS: The Regents Press of Kansas, 1979).

3 David Mowery and Nathan Rosenberg, *Technology and the Pursuit of Economic Growth* (Cambridge: Cambridge University Press, 1989), p. 128.

4 According to Cohen and Noll: "Government now accounts for about 45 percent of total R&D in the United States; in most other advanced, industrialized economies the share of government in total R&D varies from 36 percent (Germany) to 54 percent (Italy). The primary exception is Japan, where only 20 percent of national R&D is paid for by government; however, this figure is misleading because of the coordinating function of the government." Linda R. Cohen and Roger G. Nell, "R&D Policy," Center for Economic Policy Research, Publication No. 298, Stanford, CA, August 1992, p. 11.

5 See Harioff Grupp, "Efficiency of Government [intervention in Technical Change in Telecommunications: Ten National Economies Compared," *Technovation*, vol. 13, No. 4, 1993, pp. 192-193.

6 See Lewis M. Branscomb (cd.), *Empowering Technology: Implementing a U.S. Strategy* (Cambridge, MA: The MIT Press, 1993), p. 8. See also, Linda R. Cohen and Roger G. Nell, "Privatizing Public Research: The New Competitiveness Strategy," *Scientific America*, forthcoming, 1994. With respect to the need for such a policy shift, see John Alic et al., *Beyond Spinoff: Military and Commercial Technologies in a Changing World* (Boston, MA: Harvard University Press, 1992); and Nathan Rosenberg and W. Edward Steinmueller, "Can Americans Learn To Become Better Imitators," Center for Economic Policy Research, CEPR Publication No. 117, Stanford University, Stanford, CA, January 1988.

7 For an in-depth discussion, see U.S. Congress, Office of Technology Assessment, *Defense Conversion: Redirecting R&D*, OTA-ITE-552 (Washington, DC: U.S. Government Printing Office, May 1993).

8 Responding, in part, to these problems, the National Competitiveness Act of 1993 includes a title, called "Critical Technologies," which authorizes the Department of Commerce to develop a formal process of technology 'benchmarking' whereby the scientific and technological capabilities of American firms would be compared to those of other nations. Branscomb, op. cit., footnote 6, p. 20.

9 As noted by Cohen and Noll: ". . designing efficient R&D policies is quite difficult and requires trading off several conflicting objectives. There is a relatively strong case for supporting fundamental R&D that broadens society's broad technological base and widely disseminating the results to maximize their spillover value; however, one must guard against policies that are too disconnected from technical application or that, due to lack of profitability to the innovator, are not attractive to those who might apply the results. Likewise, substantial efficiencies are theoretically possible from targeting particular types of technologies for assistance; however, as a practical matter, the government may not be able to identify them to confine support to the most promising areas and to manage them efficiently.'" op. cit., footnote 4, p. 8.

of R&D and support for technology diffusion will need to be determined on a case-by-case basis.[10] In these circumstances, there is a danger that such choices will be based on political rather than economic rationales. [11]

Communication and information technologies have genrally been high on the list of technologies meriting government promotion. Viewed as essential to defense efforts, these technologies have benefited from consistent Department of Defense (DOD) support since World War II. Recognizing that communication and information technologies constitute a national infrastructure, the government has also backed their development, providing venture capital and other incentives when private capital was unavailable. When required, the government has even done the job itself. [12]

In the past, the government fostered the building of canals, railroads, and highways. Today, many people believe it should more aggressively promote the information networks required to support economic commerce.[13] Policies designed to meet such objectives should not necessarily be modeled on the past, however. Today, such policies will need to take into account the many technological, economic, and social changes that have taken place - in particular, the advances in and convergence of communication and information technologies, the conversion from a defense economy to a peacetime one, the privatization of the infrastructure, the globalization of the economy, and the rise of multinational networking providers. Policies promoting information networks will also need to reflect a greater understanding of, and appreciation for, the complex and iterative nature of both diffusion and innovation processes.

OPTION A: Use Tax Incentives To Foster Private Sector Developments

The government can stimulate electronic commerce by encouraging the development and diffusion of innovative technologies and business processes through the use of tax incentives such as tax credits, tax writeoffs, and/or accelerated depreciation schedules. By lowering the costs of technology research, development, and deployment, such mechanisms are intended to stimulate private sector activity.

Unlike technology-push strategies, which rely on government promotion of technology to create a market, tax-related incentives are designed to work indirectly through the marketplace. These measures allow private firms to control their own investment decisions. Because they are relatively simple to administer, they require little government bureaucracy.[14] In a market-oriented society

10 See Nathan Rosenberg, *Inside the Black Box--Technology and Economics* (New York, NY: Cambridge University Press, 1983).

11 As Roger Nell and Linda Cohen pointout:". . most programs are not clearly a waste of money, especially in early exploratory research. The problems arise because mid-project managerial decisions are directed from matters of economic efficiency by a host of political factors; impatience to show commercial progress, distributive politics, the inability to commit to long-term, stable programs, and a mismatch between the types of industries that are most likely to underinvest in research and those that are most attractive politically to subsidize. "Roger G. Nell and Linda Cohen. "Economics, Politics and Government Research and Development,"' Working Papers in Economics, E-87-55, The Hoover Institute/Stanford University. Stanford, CA, December 1987.

12 Highway promotion illustrates the flexibility of the government's approach and rationale. The federal government became involved in highway building as early as 1932. when Congress enacted a penny-per-gallon gas tax. The rationale and the means of financing the nation's highway system were distinct from other infrastructure projects. Presidents Hoover and Roosevelt both believed that massive spending for road construction would provide jobs during the depression. President Eisenhower justified federal support for highway construction on national defense grounds. To finance this road building program, he set up a Highway Trust Fund to be replenished from increased highway user taxes. See Rose, op. cit., footnote 2.

13 The Clinton Aministration, for example, has singled out communication technologies, automobiles, and high-speed rail for special attention.

14 Branscomb, op. cit., footnote 6, p. 18.

such as the United States, this approach has proven especially popular. In some other countries, however, it is much less in vogue.[15]

Preferential tax treatment to subsidize private sector R&D was first provided for in 1981 with the passage of the Economic Recovery Tax Act of 1981.[16] As described in the 1981 House Report 4242, this tax credit was intended to "reverse [a] decline in research spending by industry" as well as "to overcome the reluctance of many ongoing companies to bear the significant costs of staffing and supplies, and certain expenses such as computer charges, which must be incurred to initiate or expand research programs in trade or business."[17] In addition to the tax credit, the Economic Recovery Tax Act also created an accelerated cost recovery system for capital expenditures. Unlike tax credits, which are applicable to all aspects of R&D, accelerated cost recovery is limited to capital expenses alone.[18]

Today, firms can receive a credit of 13.2 percent (or a 20-percent credit, 50 percent of which is treated as taxable) for the excess of R&D over the base amount for that year.[19] The cost to government constitutes a relatively small proportion of total federal R&D funding. (For one estimate of this cost see table 5-1.) Few begrudge these expenditures, and many have called for an increase in the amount.[20] Tax incentives also have the support of the Clinton Administration, which has announced that it plans to implement a permanent R&D tax credit, selective investment-tax credits, modification of capital gains taxation, and similar macroeconomic incentives.[21]

Notwithstanding the popularity of tax incentives, there is no definitive evidence to show that they have had their intended effect.[22] Although most analysts agree that R&D spending increased after 1981, this increase is not necessarily attributable to tax incentives alone.[23] For example, some analysts have argued that, instead of undertaking new areas of research and development, businesses merely shifted their focus to take better advantage of government incentives. Measuring the impact of tax incentives on innovation itself is also extremely difficult. Innovation is multidimensional, depending for its success on a wide range of inputs such as management structure, quality control, marketing strategy, and the level of employee creativity.[24] Weighing any benefits against the cost of employing this approach is also

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15 See Dennis Patrick Leyden and Albert N. Link, "Tax Policies Affecting R&D: An International Comparison," *Technovation*, vol. 13, No. 1, 1993, pp. 17-25.

16 Cohen and Nell, op. cit., footnote 4, p. 12.

17 See U.S. Department of Commerce, Office of Technology Policy, "Analysis of the Research Tax Credit," Mimeo., Apr. 6, 1990.

18 See Leyden and Link, op. cit., footnote 15.

19 Committee on Technology Policy Options in a Global Economy, *Prospering in a Global Economy: Mastering a New Role* (Washington, DC: National Academy Press, 1993).

20 Committee on Technology Policy Options in a Global Economy, *Mastering a New Role: Shaping Technology Policy for National Economic Performance* (Washington, DC: National Academy Press, 1993).

21 Ibid.

22 The four major time series studies that have examined the impact of tax incentives conclude that there has been a significant benefit. On the other hand, this conclusion is at odds with studies that focus at the microeconomic level. Ibid., p. 20.

23 Ibid,

24 Innovation is not a linear process; rather, it is an ongoing process that entails a number of feedback loops. As described by Dominique Foray: ". . . the diffusion process itself is fundamentally dynamic and will generate, via a series of mechanisms, the continual improvement of the given technology." Dominique Foray and Christopher Freeman, *Technology and the Wealth of Nations: The Dynamics of Constructed Advantage* (London, UK. Pinter Publishers, 1993), p. 3. See also, OECD, The Technology/Economic Program, *Technology and the Economy: The Key Relationships* (Paris, France: OECD, 1992). esp. ch. 2, "Technology Diffusion."

problematic because the total cost of such programs is similarly subject to debate.[25]

Tax incentives to encourage the diffusion of networking technologies for electronic commerce might well be designed to play a more decisive and definitive role. Whether or not diffusion and innovative changes occur depends as much on the ability of an organization to '*absorb" change as it does on the nature and quality of the technology to be deployed. Firms are likely to absorb more if investments in intangibles—such as in-house R&D, worker training, patents, and software development—match investments in capital equipment.[26] Thus, the government might enhance the overall benefits to be derived from tax credits if it were to incorporate intangible investments in its tax-related provisions to a greater extent.[27]

Such a policy would be particularly beneficial to small firms that generally are less able to respond positively to technology change. Over the long term, the national economy will also benefit from increased productivity. American firms are often less apt to invest in intangibles, especially workforce training, than are firms in other countries. Thus, in a comprehensive survey of the use of computerized automation in metal-working industries, it was found that, in 84 percent of the cases examined, workers were not given any training to upgrade their skills.[28] Yet studies show that such investments can yield five times the benefits from deploying new technology.[29]

TABLE 5-1: The Federal R&D Tax Credit (in millions of 1982 dollars)

Year	Outlay equivalent of federal tax credit	Revenue loss
1981	220	16
982	640	415
983	696	590
984	3106	,276
985	2,179	,493
986	2004	594
1987	2,300	1 580
1988	1,020	740
1989	1,255	903
1990	1,233	846
1991	1,220	839

SOURCE Science and Engineering indicators–1991 p 334

OPTION B: Encourage Private Sector Activity by Providing Grants and Loans

The government can also provide financial incentives through grants and loans to the private sector. This option is very much in keeping with the recent shift in technology policy to favor research and development that aims to support commercial

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25 For some of these differences, see U.S. General Accounting Office, *Tax Policy and Administration: The Research Tax Credit Has Stimulated Some Additional Research Spending* (Washington, DC: The U.S. Government Printing Office, 1989), as compared with J.J. Cordes, "Tax Incentives and R&D Spending A Review of the Evidence,Research Policy, vol. 19, 1989, pp. 119-133.

26 As described in a recent OECD analysis "If the full value of investments in new equipment is to be gained, then physical and intangible investment should be closely I inked. In-firm training and investments in the reorganization of work and in software should accompany physical investment at the firm level, to ensure that equipment is used effectively and that the productivity potential of the equipment is reaped." OECD, op. cit., footnote 24, p. 1 I 9.

27 According to the OECD ". . . a number of countries are now looking carefully at training incentives and incentives to improve human resource management. In some cases, incentives have been introduced to widen firm-based training. Most other expenditures on intangibles (organizational costs, engineering, and marketing) can be deducted from taxable income as they are Incurred, and they are now favored [~\ er physical investment. However, as firm strategies give more emphasis to a whole range of intangibles, the question of whether the balance of government policy investment incentives and disincentives is correct must be addressed" I hid., p. 133.

28 M. R. Kelly and H. Brooks, *The State of Computerized Automation in U.S. Manufacturing* (Cambridge, MA: Harvard University Press, 1988).

29 OECD, op. cit., footnote 24, p. 129.

needs. Like tax incentives, it relies for the most part on "demand-pull" rather than "technology-push" to achieve its ends; in many cases, it is the private sector that initiates, and the government that responds to, funding proposals.[30] To assure an appropriate balance between public and private sector goals, financing is provided on a matching basis.

The Advanced Technologies Program (ATP), administered through the National Institute for Standards and Technology (NIST), provides a good example of this type of research arrangement. ATP, which was established by the 1988 Omnibus Trade and Competitiveness Act, provides small grants to companies or groups of companies to undertake "high-risk, high-return research on precompetitive, generic technologies" that have a good chance of being commercialized. Proposals are generated by the private sector. In evaluating proposals, NIST favors neither specific industries nor technologies; instead, it evaluates projects on the basis of whether or not they are technically superior and show business promise.[31] However, in the projects funded to date, there has been a clear bias in support of proposals from "high-tech" industries such a microelectronics, superconducting materials, and biotechnology .[32]

The ATP has had a promising start. However, it has not yet demonstrated whether or not the high-risk projects will have enough upstream support to successfully make it to market. One possible constraint may be a lack of funding.[33] To date, ATP funding has been increased from $10 mill ion in fiscal year 1990 to $68.9 million in fiscal year 1993.[34] However, had Congress enacted the NIST authorization bill for fiscal year 1994, the program would have received $1.5 billion over a 5-year period.[35]

The Technology Reinvestment Program (TRP), while similar to ATP, is more technology directed. Its aim is to ● 'stimulate the transition to a growing, integrated national industrial capability which provides the most advanced, affordable, military systems and the most competitive commercial products." Although supported by five departments and agencies, TRP is administered through the Advanced Research Projects Agency (ARPA), formerly the Defense Advanced Research Projects Agency (DARPA).[36] TRP's focus is dual-use technologies, but the criteria for project selection

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30 Describing this rationale, Branscomb and Parker note: "In a well-designed program there should be an industry role in choosing, executing and funding projects. Since it is industry that has the ultimate responsibil ity to bring a technical product to fruition, any program that is to succeed in helping industry must be oriented toward industry needs. There is no more effective way to do this than to have industry's input into the decisions that determine the choice of projects." See Lewis M. Branscomb and George Parker, "'Funding Civilian and Dual-Use Industrial Technology," in Branscomb, op. cit., footnote 6, p. 79.

31 Ibid., pp. 82-84.

32 Cohen and Noll, op. cit., footnote 6, p. 2.

33 As assessed by the Committee on Science, Engineering, and Public Policy: "The ATP program has had a promising start. It is not possible, at this early stage, to determine the program's success; nor should congressional or executive branch pol icymakers expect to see immediate, dramatic results. The panel has concluded, however, that the ATP's budget in the past has been insufficient to have a significant impact on U.S. technology commercialization efforts." Committee on Science, Engineering, and Public Policy, *The Government Role in Civilian Technology: Building a New Alliance* (Washington, DC: National Academy Press, 1992).

34 Committee on Technology Policy Options in a Global Economy, *Mastering a New Role: Shaping Technology Policy for National Economic Performance*, op. cit., footnote 20, p. I 06.

35 Ibid., p. 107.

36 These agencies include the Departments of Defense, Commerce, and Energy, as well as the National Science Foundation and the National Aeronautics and Space Administration. In addition to the technology development programs within TRP (which receive 45 percent of all funds), there are programs for technology deployment (which receive 45 percent of all funds), and manufacturing education and training (which receive 10 percent of all funds).

are flexible and in keeping with DARPA's well known and highly commended style of project management.[37] Projects may be joint commercial-military in nature, or they may focus on private technology development and/or engineering education. In all cases, participants are required to contribute 50 percent of the costs. In fiscal year 1993, the TRP received funds totaling $472 million. President Clinton has announced his intention to increase funding to $600 million for fiscal year 1994.

There are a number of advantages to programs that encourage greater private sector participation in the funding, selection, and execution of research and development tasks. Studies have shown, for example, that research and development is more likely to enhance economic growth and productivity when businesses, themselves, play a major role.[38] This is not surprising because R&D is an intangible investment; when businesses conduct R&D, they have greater capacity to innovate and absorb technological advances.[39] A greater role for business is also called for, insofar as R&D is intended primarily to achieve a commercial goal. As the history of U.S. government technology policy makes clear, the federal government has a poor record of anticipating which technologies are 1ikel y to become commercial Successes .x)

One aspect of these programs that merits greater scrutiny, however, are the provisions for intellectual property rights. Unlike previous government R&D programs, which provided that the results remain in the public domain, many new programs transfer all of the intellectual property rights to the participating businesses.[41] This trend may be counterproductive. One of the reasons why government invests in R&D is to reap the gains that result from "knowledge spillovers." The gains may be less, however, if the knowledge generated by R&D is kept proprietary.[42] Establishing intellectual property rights is especially important in the development of networking technologies. These rules will not only have an impact on firms doing research; they may also have a negative affect on standardization and network interoperability.[43]

OPTION C: Stimulate the Market by Leveraging Procurement Powers

Government procurement combines the effects of "technology push" and "demand pull." Because the federal government is one of the largest purchasers of both communication and information technologies, it has considerable leverage in these markets. Using this leverage, the government can influence the design, development, and deployment of technologies to support electronic com-

[37] DARPA was established with in the Department of Defense in 1958 in response to the Sputnik Crisis. Its goal was to foster "advanced project essential to the Defense Department's responsibilities in the field of basic and applied research and development which pertains to weapons systems and military projects." As described by John Alic et al,: "DARPA is unique within the Defense Department in that it has a minimum of administrative layering and gives Its program managers wide discretion to support technologies the> consider promising. It operate's no laboratories of its own, and until 1987 did not even have the ability to execute its own contracts, relying instead on the sin-\ ices to act as its contracting agents." Alic et al., op. cit., footnote 6, p. 138.

[38] See OECD, op. cit., footnote 24, p. 127.

[39] Ibid. see also Mowery and Rosenberg, op. cit., footnote 3.

[40] Cohen and Noll, op. cit., footnote 4.

[41] Using the Advanced Technology Program as an example, Cohen and Noll point out: "ATT originally emphasized 'generic Pre-c(~n~P'tl tive' research. however, the emphasis 1$ now on 'high risk' research. In line with its competitiveness angle, ATP keeps the details of its projects proprietary. Any resulting patents are owned by participating companies, although the government retains '-march-[n-rights"' (i.e., It can take away patents if the contractor fails to commercialize the technology within a specified period of time) and can require the contractor to license its new technology." Cohen and Nol 1, op. cit., footnote 6, p. 3.

[42] Ibid.

[43] Joseph Farrell, "Standardization and Intellectual Property," Hoover Institute Working Paper No. ED-89-25, August 1989.

merce, The government's demand can have an impact either directly, through the creation of new products and industries, or indirectly, through the knowledge spillovers that occur when new products and processes are more widely diffused throughout the economy.[44]

The impact of government procurement on the development and evolution of communication and information technologies has been greatest in the area of defense. It was, in fact, to meet its wartime needs that the federal government first turned to the private sector to develop technology.[45] Mirroring defense needs, funding was concentrated in specific industries, such as aircraft and missiles (50 percent) and electrical equipment (25 percent). This allocation favored communication and information technologies, which account for almost the entire electrical equipment category.[46]

Leveraging DOD's procurement power has proved especially effective in the case of new and rapidly advancing communication technologies.[47] Had emerging businesses not been able to count on the DOD for a large, guaranteed market, many industries would have been unable to rally the sizable investments required to develop such state-of-the-art technologies as early satellites, computers, and semiconductor chips.[48] Having a large market in the early stages of product development may also have helped to lower the barriers to entry, increasing competition and allowing many small and innovative companies to share in the defense contracting market.[49] Knowledge spillovers were also greatest in the earliest stages of technology development when military and civilian needs overlapped.

With the shift in the focus of national priorities from security to economic competitiveness, defense procurement has become an increasingly inadequate mechanism for promoting communication and information technologies. As these technologies have matured, civil and defense applications have diverged. Greater tradeoffs between them are now required and there are fewer knowledge spillovers. Moreover, high-risk, advanced technologies—the area of development in which DOD has excelled the most-do not constitute a major barrier to the evolution of electronic commerce. There is, however, a need for more

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44 Cohen and Noll, op. cit., footnote 4, p. 16.

45 As Mowery and Rosenberg point out, until 1940, most government research and development was carried out by the civil service in agencies such as the National Bureau of Standards, the Department of Health Services, or by state institutions financed by federal grants such as agricultural experiment stations. Op. cit., footnote 3, p. I 23.

46 Recently, however, there has been a shift from public sector funding to private sector funding of these technologies. Ibid., p. 137.

47 See Alic et al., op. cit., footnote 6.

48 Describing the case of integrated circuitry, Mowery and Rosenberg note: "'The large procurement needs of the military and NASA and the increasing concern with the importance of miniaturization were vital in the early years of new product development in electronics. The Signal Corps was the largest military purchaser of semiconductors in the early and mid 1950s. . . . In the first year of integrated circuit production, the federal government purchased the entire $4 million of output. It remained the largest buyer for the first 5 years, although the government share declined rapidly. . . . By the end of the I %0s, the rapidly growing computer industry displaced the military as the largest end user market for integrated circuits. " Mowery and Rosenberg, op. cit., footnote 3, p. 145. See also, Richard R. Nelson (cd.), *Government and Technical Progress: A ~'rc~,~.s-ltl~lli.sir? Analysis* (Elmsford, NY: Pergamon Press, 1982); and Kenneth Flamm, *Creating the Computer: Government, Industry, and High Technology* (Washington, DC: Brookings Institution, 1988).

49 Ibid.

rapid and effective technology diffusion within commercial settings. In this area, DOD's record is not particularly strong.[50]

This is not to say that DOD has no role to play in the promotion of electronic commerce. As a major government buyer, DOD can lead the way in using networking technologies for both product development and commercial exchange. Within DOD, efforts are already underway to promote a commercial infrastructure to support electronic commerce through the Continuous Acquisition and Life-Cycle Support (CALS) initiative. Originally fashioned to provide DOD computer-aided logistical support, this effort has recently been expanded and reconceived as a technical, standards-based platform to support enterprise integration and electronic commerce.[51] Linking DOD to its suppliers and its suppliers to one another, CALS fits well into the technology policy shift from defense to dual-use technologies.[52]

In like fashion, the General Services Administration (GSA), which is responsible for $10 billion in annual purchases, can take advantage of networking technologies to enhance its procurement process. Network technologies for electronic commerce are coming on line at the precise moment when many people are proposing new ways to restructure GSA's procurement operations. Just as many businesses are using networking technologies to help them reengineer for higher performance, GSA could employ these technologies as a catalyst for organizational change,[53]

OPTION D: Directly Fund, Develop, and/or Provide Needed Technologies and Technology-Related Services

Government can also help to stimulate electronic commerce using a "technology-push" strategy. Although such an approach was common in the past, it is likely to be less applicable in the future. There is no longer a single communication "network" to support. Instead, networks are comprised of a variety of converging digital technologies that are being unbundled and repackaged for sale by a wide variety of competing industry players. As past experience indicates, when widespread diffusion and continuing innovation are the goal, a technology-push strategy will not suffice. However, with these limitations in mind, such an

[50] As described by John Alic "Defense's way of doing business provides little guidance for coping with the pressures of the new international economy. Defense technologies take their cues from government "requirements, not from a competitive market. DoD emphasizes functional performance objectives over schedule and cost; one consequence is that it spends five times more on R&D, as a fraction of total system costs, than commercial firms do. Major defense projects extend over a decade or more, much longer than in civilian industry. Defense programs tend to follow a 'pipeline' progression, in which a separately funded and managed R&D phase precedes production. In contrast, commercial businesses are constantly improving their products, pursuing R&D in parallel with production and feed in new technology incrementally." Alic et al., op. cit., footnote 6, p. 17.

[51] As described in the CALS Strategic Plan: "official definitions of CALS have had a difficult time keeping up with 'CALS, the concept.' Initially, about 1985, CALS focused on *logistics* as computer-aided logistics support." Over time, CALS technologies were extended to include weapons acquisition systems, so that by 1988 CALS came to be defined as a "computer-aided acquisition and logistics support." Later, when design processes were included together with weapon systems production and support processes, giving rise to the discipline of concurrent engineering, CALS was renamed CALS CE. Most recently, CALS has been redefined as "computer-aided acquisition and logistics support" to take into account advances in other information technologies, such as electronic data interchange. DOD, "CALS Strategic Plan," Final Coordination Draft, Oct. 28, 1993.

[52] As described by Brian Kahin "CALS encompasses a broad set of standards development activities undertaken in conjunction with NIST and the private sector. CALS seeks to develop dual-use standards that will enable DOD to build on the civilian technology base while implementing a DOD-wide platform for automating weapons design, procurement, deployment, and maintenance. Thus CALS supports integration between the defense economy and the civilian economy, between DOD and its contractors (and subcontractors), and among the fragmented and bureaucratized procurement and logistics offices within the different services of the United States military." Brian Kahin, "Information Technology and Information Infrastructure," in Branscomb, op. cit., footnote 6, pp. 141-142.

[53] For a discussion of GSA's role in procurement and its use of information technologies, see U.S. Congress, Office of Technology Assessment, *Making Government Work: Electronic Delivery of Federal Services*, OTA-TCT-578 (Washington, DC: U.S. Government Printing Office, September 1993).

approach can serve to "prime" the development and deployment processes at the outset, demonstrate the viability of new technologies and applications, and meet social needs for which a market is unlikely to develop.

Technology-push strategies are generally mission oriented and often closely linked to the agencies charged with executing a specific goal. Thus, the goal of fuel efficiency is associated with the Department of Energy, space exploration with the National Aeronautical and Space Administration (NASA), and weapons production with DOD. In contrast, because communication and information technologies are used to support so many different kinds of activities, a number of agencies have supported their development. These include NIST, the National Science Foundation (NSF), NASA, ARPA, several government laboratories, the National Library of Medicine (NLM), and more recently the National Telecommunications and Information Administration. With the recent emphasis on competitiveness issues and defense conversion, however, many now look to ARPA to play a lead role.[54] This tendency will likely be even more pronounced in the case of electronic commerce because ARPA has strong programs to support the development of both networking and manufacturing technologies.

One ARPA-originated program that is often held up as a model for "technology-push" strategies is the Internet (previously ARPANET). Although government provided the initial funding, the private sector will be able to assume more of this responsibility as the network gains critical mass. While clearly a model of success, the case of the Internet also points to some policy issues that can be associated with technology-push strategies.

The Internet is a global computer network that provides technical compatibility and transparent connectivity based on a widely used suite of protocols-TCP/IP[55] (see box 4-5 in chapter 4). It is currently comprised of approximately 5,000 networks to which 500,000" computers are connected.[56] Originally funded through ARPA, and later NSF, to support defense communication and research, the Internet today serves as a worldwide communication network that provides a platform for the del ivery of a wide range of services, a number of which are now being provided on a commercial basis.

As the only nonproprietary global network capable of providing technical compatibility and transparent connectivity, the Internet rapidly grew in size. By the late 1980s, the university market had reached a saturation level and commercial de-

[54] For a detailed description of the history and activities of ARPA, see "ARPA: A Dual-Use Agency," in OTA, *Defense Conversion*, op. cit., footnote 7. Describing ARPA's growing popularity, the OTA report notes: "ARPA's reputation for successfully identifying and supporting risky technologies with significant king-term benefits has led some people to suggest that the agency be given broader purview over technology development, While some proposals have called for removing ARPA from DOD and giving it a civilian mission, most have pushed for a more explicit broadening of ARPA's dual-use responsibility while keeping it within DOD. . . . The 1993 Defense Authorization Act also expressed a sense of the Congress that DARPA be renamed ARPA, with responsibility for researching innovative technologies applicable to both dual-use and military missions, and for supporting development of a national technology base. President Clinton implemented the first portion of this recommendation, renaming the agency ARPA in March 1993." p. 142.

[55] As described by Brian Kahln: "The Internet is defined functionally rather than institutionally. It is the set of interconnected networks that support the interoperation of three basic functions: remote log-in, electronic mail, and file transfer. It is not limited to TCP IP networks; networks supporting 0S1 or other protocols are part of the Internet if they interoperate with the predominant TCP 1P Internet through protocol conversion." Brian Kahin, "In nformation Technology and Information Infrastructure," ch. 5, in Branscomb, op. cit., footnote 6, pp. 135-167.

[56] See Toni Valovic, *Corporate Networks: The Strategic Use (~' Telecommunications* (Boston, MA Artech House, Inc., 1992), pp. 116-165. The Internet is organized hierarchically. At the top are the backbone networks, the largest of which is NSFNET. At the next let'el down are the mid-level network, which support regional connectivity. At the bottom are local networks, based in specific institutions. The Internet authority structure is very loosely coupled. Although each network is responsible for connectivity to the next higher level, administrative decisions are decentralized and individual networks are therefore highly diverse. See Hay Habegger, "Understanding the Technical and Ad]] inistrative Organization of the Internet,"' *Telecommunications*, February 1992, pp. 12-13.

mand was on the rise .57 Once demand had reached this critical mass, firms entered the market to meet it.[58] one key player, for example, was Advanced Network Services (ANS)—a nonprofit joint venture between IBM, MCI, and Merit Networks—which was established in 1990 to operate the NSF backbone. In May 1991, ANS spun off a for-profit subsidiary, ANS CO+RE Inc., to develop a T3 Internet backbone. The subsidiary would be allowed to sell the excess capacity to commercial users. Equally important, in 1991, Performance Systems International (PSI), BARRNET, CERFnet, and UUNET Technologies (later followed by Sprint) joined together to form the Commercial Internet Exchange Association (CIX) to provide interconnect ion between their commercially oriented services. Today, 60 percent of all registration domain names on the Internet are those of commercial organ izat ions .[59]

While allowing the government to reduce the level of its financial support, commercialization of the Internet also raises a number of issues. For example, some people in the research community began to protest that their networking costs were likel y to increase. Others were alarmed that the decentralized, collegial structure. which has characterized the administration of the Internet, could not survive in a commercial environment. They questioned how researchers' needs for openness and accessibility would be traded off against business needs for data security, and whether—in a cost-based, commercial environment—significant emphasis would be placed on deploying the most advanced, cutting-edge technologies.[60]

The commercialization of the Internet also raises a number of regulatory issues. Because the Internet now functions as a ubiquitous worldwide data network, decisions must be made about its relationship to other aspects of national communication policy.[61] Issues will also need to be resolved with respect to the providers of services. Because of ANS's early role in managing the Internet, some have accused NSF of favoritism in its selection of providers.[62] As commercialization makes Internet traffic increasingly more lucrative, competition—and the debate over the rules that govern it—will also become more and more intense.

The Internet experience may prove to be much less transferable than many have surmised. Its rapid growth was due not only to common standards and government support, but also to the

[57] Alton Hoover, "Scenarios for Internet Commercialization," *Tele({~nln]l~nil{lt/ens,* February 1992, p. 19.

[58] See, for discussions, William Schrader anti Mitch Kapor, "The Significance and Impact of the Commercial Internet," *Telecommunications*, February 1992, pp. 16-17, Hoover, op. cit., footnote 57, pp. 18- 19; Gary H. Anthes, "Commercial Users Move (into Internet," *Computerworld*, Nov. *2.5, 1991,* p. 50. and Ellen Messmer, "Industry Asks for NREN To Support Commercial Needs, " *Network World*, Oct. *9, 1991,* pp. 4, 43.

[59] Schrader and Kapor, op. cit., footnote 58, p. 17.

[60] See Susan M. Eldred and Michael McGill, "Commercialization of the Internet/NREN: Introduction," *Electronic Networking: Research, Applications and Policy, vol.* 2, No. 3, fall 1992, pp. 1-2.

[61] As described by Kozel "How the more commercialized Internet will be regulated is itself being debated. The Internet has evolved with little regulation other than the good manners implicit m peer pressure and self-policing among equals. This system may not hold up in an era when commercial users paying for service inevitably have problems that need to be arbitrated. Closely monitored FCC-type regulation is not likely, yet the need for an authority to resolve such problems is already at hand.'" Edward R. Kozel, "Commercializing the Internet: Impact on Corporate Users," *Telecommunications*, January 1992, p. I I.

[62] Sharon Fisher, "Access Providers: ANS Has Unfair Edge," *CommunicationsWeek, Dec. 23, 1991,* p. 5. As Branscomb and Parker have pointed out, fairness is especially important in mission-oriented research and development. As they note: "In these cases the assumption is usually made that the desired activities will ultimately he carried out by the private sector. The justification for such R&D is compensation for externalities the market does not adequately address. The constraint on the appropriateness of federal R&D investments, once Congress has authorized the program, is supplied by standards of effectiveness and fairness."' Lewis Branscomb and George Parker, "Funding Civilian and Dual-Use Industrial Technology, In Branscomb, op. cit., footnote 6, p. 68.

unique environment in which it blossomed.[63] The first community of users were highly skilled, technical people who tend to be early adopters of new technologies. These users were also contributors to the design and development of the Internet, an ongoing and innovative process that continues today. Although this factor was probably essential to the Internet's success, it may also be the most difficult aspect of the Internet model to replicate.

Building on its past efforts to promote the Internet, the government is now supporting a number of projects that are designed to develop applications that will run over the Internet or other value--added networks. Many of these relate to electronic commerce. For example, in 1991, the Air Force initiated a program to develop an electronic procurement system called Government Acquisition Through Electronic Commerce (GATEC). This project is part of a larger ongoing joint effort started in 1989 by DOD and Lawrence Livermore National Laboratory (LLNL) entitled "Electronic Commerce through Electronic Data Interchange (EC/EDI)."[64]

GATEC capitalizes on LLNL's complex systems integration and computer security expertise and successful technology transfer. The technology, now fully deployed and in use with hundreds of vendors at Wright-Patterson Air Force Base, is wholly government-owned and employs the services of seven value-added networks (VANS). It is interesting to note that VANS were used for the convenience of small suppliers who could neither afford the cost of direct Internet access nor handle its complexity. GATEC's innovative design with off-the-shelf gateways and personal computers permits the exchange of e-mail-based electronic data interchange without regard to the specific hardware and software systems used.

Government may also choose to develop products and services that meet specific social goals to which the market is unlikely to respond. One such project, for example, is the Visible Human Project. This project is funded through the federal High Performance Computing and Communications Program as one of its Grand Challenges. Participants will create an electronic "image library" consisting of three-dimensional images of the male and female body, which will be accessible through computers and computer networks.[65] Over the longer term, it will link the structural-anatomical data depicted by images to the functional-physiological knowledge that exists in text-based databases.

The designers of the Visible Human Project deliberately chose to have the government fund the database development costs in their entirety. Four principles governed this decision: 1) medical information is a public good and should be readily accessible; 2) the quality and integrity of NLM's data must be protected at all times; 3) American health professionals should have equal access at equal prices to this information; and 4) to the degree possible, the costs of gaining access should be shared appropriately by the biomedical community.[66] To assure Widespread availability, users

63 Hoover, op. cit., footnote 57.

64 DOD has invested about $ 15 million in the EC/EDI projects over 4 years, with about 20 percent of it having ken spent on the GATEC pilot site.

65 In the first phase, the University of Colorado, under contract, will supply Computerized Tomography (CT), Magnetic Resonance Imaging (MRI), and cryosection images of a representative male and female cadaver at an average of one mill imeter intervals. This data will occupy about 70 to 80 CD-ROMs and wi II I ikely be made available via the Internet. National Library of Medicine, "The Visible Human Project," Fact Sheet, April 1993.

66 National Library of Medicine, "NLM Policy on Database Pricing," January 1993.

will be charged an access fee that is set at "the lowest feasible price."[67]

Even when serving the interests of the public-at-large, government funding of these kinds of information services can create problems with the private sector, especially if the information has economic value. Although the government has met with little resistance in the case of the Visible Human Project, it has encountered problems in developing other medically related databases that contain information about medical devices or drugs that might be considered proprietary. Concerns about proprietary rights in information have, for example, forestalled efforts by the NLM to begin a clinical trials database. Many of these trials are sponsored by drug companies who consider even general knowledge about the existence of the trial to be proprietary.

When funding social programs, issues will necessarily arise with respect to making choices between social goals. Because there are no formally agreed-upon criteria, decisions are often politically based, depending on which constituencies have the most financial resources and political power. As a result, some groups have been underfunded compared with others. Among them are small businesses, nonprofit organizations, and labor. Although NTIA has recently established a grant program to help nonprofits establish interconnection through the national information highway, this program calls for matching funds of 50 percent. This requirement may well be beyond the means of many organizations, and may defeat the program's purpose.

[67] In 1989 the Board of Regents, the civilian oversight body for NLM, put together a blue-ribbon panel on electronic imaging. This panel recommended that the project be completely funded by government on the grounds that medical information should be readily accessible to all. National Library of Medicine, Board of Regents. "Electronic imaging: Report of the Board of Regents," U.S. Department of Health and Human Services, Public Health Service, National Institutes of Health, NIH Publication 90-2197, 1990.