Chapter 9

International Support for Programmable Automation

Contents

Tables

Figures

Chapter 9

International Support for Programmable Automation

Summary

Many of the industrialized nations support the development of programmable automation (PA) to some extent. The degree to which such support has been effective is not easy to determine. It is confounded by other factors, including technological sophistication, industry characteristics, and cultural differences. However, the efforts which seem to be most successful are those which conform to and build on existing social and economic traditions.

The Japanese Government, mainly through the activities of its Ministry of International Trade and Industry (M ITI), has developed long-range plans for economic growth, productivity growth, and export competitiveness. The most notable contribution of MITI has been to encourage the diffusion of PA technologies to small and medium-sized firms. In this way MITI has also stimulated low-cost, mass production of the low-end products of the PA market. This has helped Japanese producers become strong competitors in the international PA market.

Since the mid-1970's, West Germany has been committed to enhancing the international competitiveness of the advanced technology sectors of its economy through strong support of research and development (R&D). The Ministry for Research and Technology (BMFT) is the lead agency for coordinating science and tecnology policy with overall macroeconomic policy goals. BMFT has established an Advanced Manufacturing Technologies Program in order to promote the riskier types of innovation in this sector. The government has placed a strong emphasis on developing an understanding of the ways in which PA will affect the workplace and the labor force.

In the 1980's, the Swedish Government began to devote more resources to long-term research in PA in the hopes of bolstering Swedish economic growth. The Swedes are already significant robot producers. The Government also has a strong interest in education and retraining, which is consistent with its traditionally strong manpower policies.

The French Government under Mitterrand has made a strong commitment to speeding up the development and diffusion of PA, in part to enhance competitiveness. Japan and Sweden have set up robot manufacturing facilities in France as part of a Government strategy for technology transfer. The French Government has also shown concern for the human impacts of the implementation of PA.

The Department of Industry and Trade in the United Kingdom has a set of "schemes" to promote capital investments in PA. To date, however, these schemes have not been notably successful in promoting the diffusion of PA in Great Britain. The Government recently set up a national advanced technology research program to support R&D in PA industries, among others.

Norway has no extensive Government programs to encourage PA, although its production and application are progressing. The Government is urging the development of new technologies to promote industrial expansion. It has also identified key social impacts that the transition to advanced technology industries is having on the labor force.

The Canadian Government is playing a large role in encouraging the development and implementation of PA. It has developed model

programs for Government investment strategies and for encouraging labor-management cooperation in dealing with dislocation, retraining, and work environment issues. The programs are new and the development effort starts from a relatively modest base.

Italy is a significant producer and exporter of machine tools and industrial robots. Some predict that Italy may also become one of the top five producers of industrial robots by the 1990's.

Introduction

Technological change and evolving patterns of international trade have focused attention on government policies relative to PA and on their potential effects on the development of manufacturing sectors among nations. This chapter describes policies and programs abroad which are directed at the development and use of PA, focusing on countries most actively engaged in PA production and use. * While other chapters discuss international comparisons in specific areas, this chapter provides complementary descriptions of major foreign government programs.

In each country discussed here, PA technologies can be found in different phases of de velopment and adoption. The rate of adoption depends on the nature of each country's manufacturing sector, the availability of appropriately skilled labor, the nature of public and private research efforts, and such factors as capital availability, awareness of the technologies and their capabilities, and government incentives to encourage implementation.

Industrialized nations have different traditions of government involvement in technology and industry development. The distinctive cultural, social, political, and economic characteristics of each nation shape its policies. The course of development among national manufacturing sectors also varies, depending on the size of the economy, the nature of the local capital market, the extent to which the economy depends on exports, and the flexibility of the labor market. These national differences make it difficult to measure and compare the effects that macroeconomic and macroeconomic policies have on a country's competitive advantage in international trade, its industrial mix, and its employment profile. International differences also militate against the direct transplantation of foreign programs to other countries. Finally, the availability of information about foreign support for PA is very uneven, and the timeliness and accuracy of that information is a recurring problem for international comparisons regarding PA. Nevertheless, this discussion is offered for illustrative purposes and to provide a measure of the level of foreign government interest in PA.

Industrial and technological development abroad appear to reflect less the dollar amount of government support than the nature of government programs and their relation to existing political, economic, and social conditions. It is not clear that current PA R&D programs in the United Kingdom and France, for example, have been notably successful. The climate for research and the mechanisms for assuring that research results are disseminated to industry in those countries may not be as favorable as in the United States. For example, the mobility of researchers between industry and universities appears to be greater in the United States. Moreover, Europeans are currently concerned that loss of their top scien-

*Note that reliable and useful information on support for ~d use of PA in Eastern bloc countries is virtually nonexistent. Hence, these countries are not included in this analysis. In addition, other countries not covered here, including many in the Third World, also produce and use PA to a limited extent. For example, the use of CAD systems for mapping applications is growing in less developed countries.

tists to the United States may diminish their prospects for economic growth.[1]

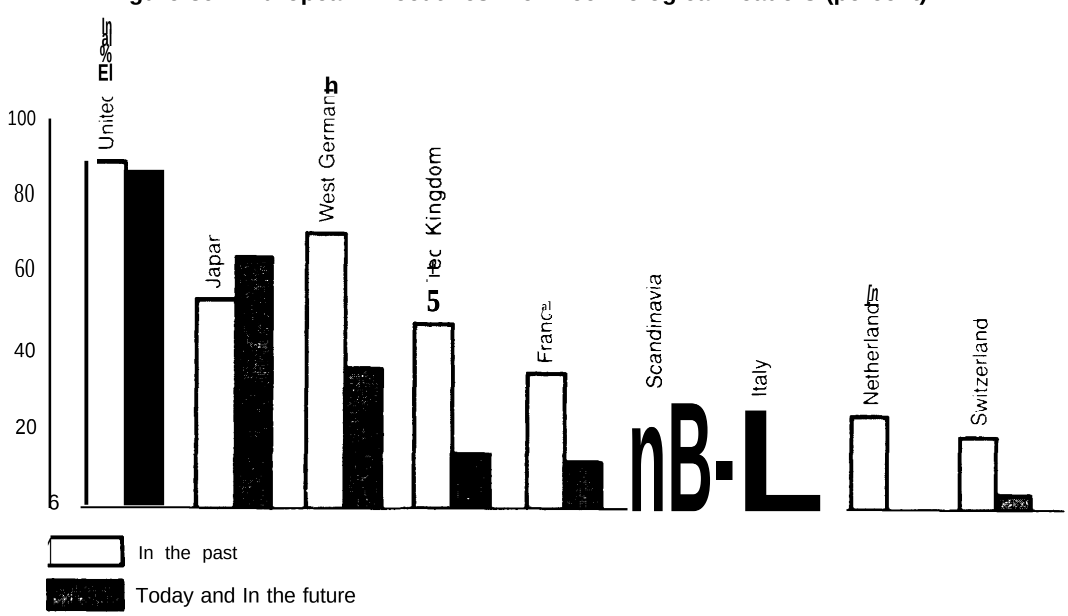
A group of more than 200 European corporate chief executives recently surveyed by the Wall Street *Journal* "believe their continent has declined as a source of technology leadership, with the U.S. maintaining its top position and Japan gaining in importance."[2] Figure 39 shows how the executives rated different nations in technological leadership. The perceived losses in technological leadership by European countries—particularly West Germany and the United Kingdom—are striking. The explanations offered by the executives surveyed include a lack of trained personnel for developing and introducing new technology; relatively low status for technology issues and technical personnel within corporations; and a strong conservatism among European businessmen. These factors result in part in an emphasis on technology for cost reduction, as opposed to innovation as a source of new products, improved product performance, or improved customer service. It is interesting to note that most of the problems cited by European executives have also been cited in similar studies in the United States.[3] According to the *Journal* survey, European executives apparently believe that U.S. corporations are responding to those problems more effectively than they are themselves, de spite domestic criticism of U.S. industry and policies.

[1] Diane L. Coutu, "European Nations Fret Over Mounting Losses of Scientists to the U.S.," *The Wall Street Journal,* Oct. 21, 1983.

[2] J. Huey, "Executives Assess Europe's Technology Decline," *The Wad Street Journal,* Feb. 1, 1984, p. 28. The Journal, Booz-Allen & Hamilton, Inc., and HR&H Marketing Research International of London selected the executives from the top 1,000 companies in Europe ranked by revenue. The *Journal's* coverage is based on responses to the survey, Booz-Allen's analysis, and the work of the *Journal's* reporting staff. The *Journal* writes: "The survey isn't intended to be statistically rigorous, but it represents probably the most comprehensive current survey of executive attitudes regarding the technology on a pan-European and multi-industry scale."

[3] See, for example, R. H. Hayes and W. J. Abernathy, "Managing Our Way To Economic Decline," Harvard Business Review, July-August 1980, pp. 67-77; R. G. Shaeffer and A. R. Janger, The Conference Board, "Who is Top Management?" report No. 821, 1982, as well as other Conference Board reports.

Figure 39.—European Executives Pick Technological Leaders[a] (percent)



[a] Respondents could choose more than one country

SOURCE The Wall Street Journal and Booz.Allen & Hamilton, Inc , survey Of more than 200 chief executives of corporations In 16 foreign countries as reported in *The Wall Street Journal,* Feb. 1, 1984, p 28

On the other hand, European countries tend to focus more attention, political support, and research on the human aspects of automation than does the United States. Attention to social issues related to PA parallels traditions in many countries of strong programs for employment security and training and prominent representation of labor groups in the political arena. Concern abroad for the employment effects of PA is high and likely to grow in light of the relatively low rates of job creation in many European countries and the labor displacement potential commonly associated with PA. Recent analyses by the Organization for Economic Cooperation and Development, for example, concluded that the United States had created 22.5 million new jobs since 1980, while industrial employment in Western Europe fell by 1.5 million in the same period.[4]

The following sections describe policies and programs in each country related to both the social and technical aspects of PA.

[4]Paul Lewis, "Nations Seek Key to Growth, " The New *York Times,* Feb. 15, 1984.

Japan

Direct Government Role

Given Japan's scarcity of indigenous natural resources and its reliance on other nations for imports of food, energy, and raw materials, the Japanese strive to maintain a high volume of exports. Thus, international competitiveness and the ability to sell abroad is of crucial importance to the Japanese economy. Over the last decade Japanese firms have made a concerted effort to increase export sales in manufacturing industries.[5] Figure 40 demonstrates how the character of Japanese exports and imports has changed dramatically in the past few decades, partly as a result of the stewardship of MITI.

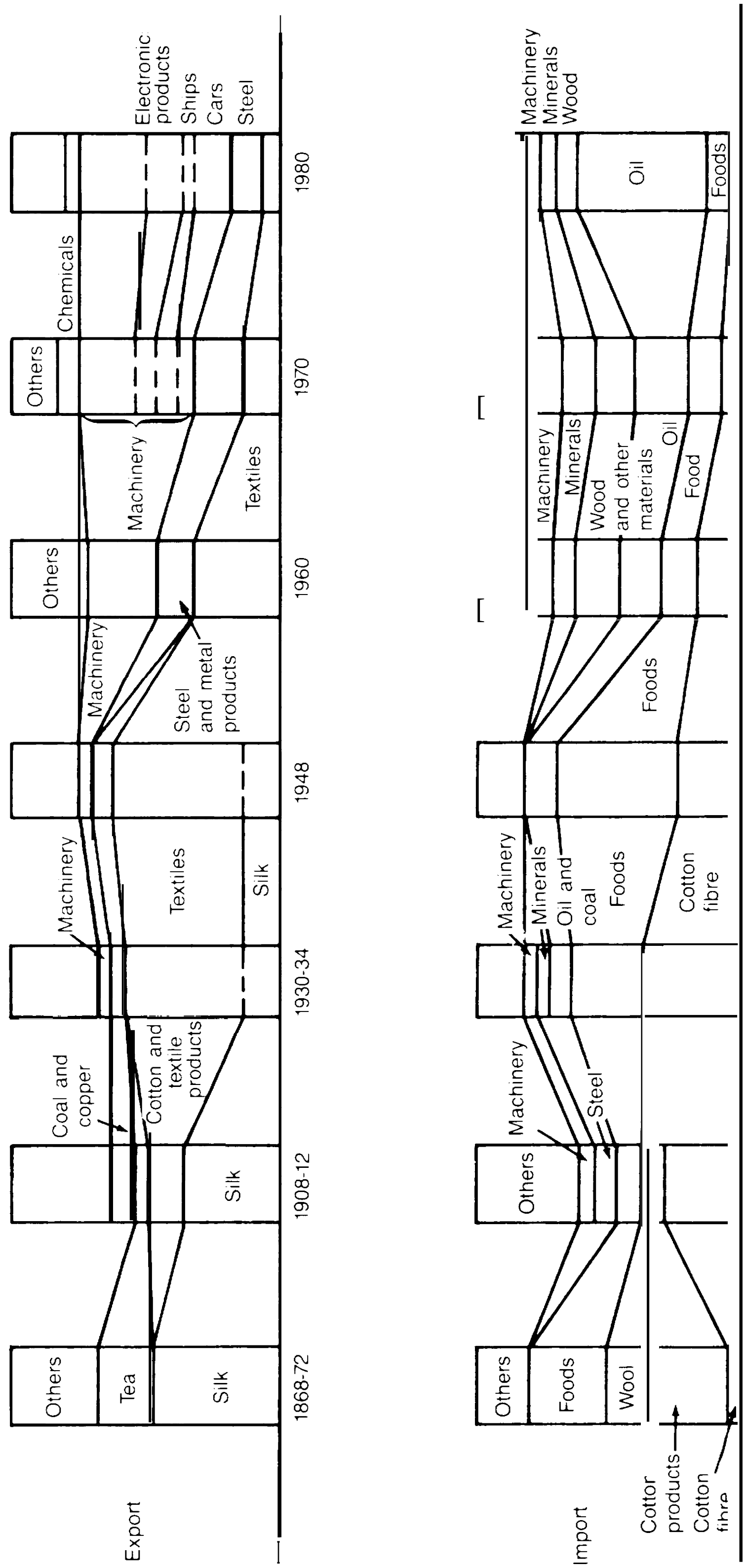
Since the Meiji Restoration in 1868, there has been a tradition of Government-industry cooperation, and the Government has historically been able to intervene effectively in the economy. Thus, industry has traditionally tended to view Government as a partner, rather than as an adversary or regulator. In recent years, however, this cooperative relationship has appeared to break down to some extent, as evidenced by the ebbing role of the Ministry of International Trade and Industry (MITI).

5 Japanese Ministry of International Trade and Industry, "White Paper on International Trade, " September 1982, p. 50.

MITI was organized in the late 1940's from the Commerce and Industry Ministry, and its name reflected a new emphasis on international trade. While the agency has less independent power than is commonly ascribed in the United States, MITI works closely with industry associations and other Government agencies. For example, a standard practice is for a former official from the MITI staff to join the staff of an industry association and act as a liaison. The agency sets broad industrial policy, collects information on relevant research in other countries, and promotes special studies where information is lacking. The observation that MITI's role maybe decreasing seems to be based on two major trends: First, the agency played a major role in allocating scarce capital in the postwar period, while capital shortages are now much less severe. Second, many Japanese industries (automobiles, for example) have become very strong; hence, they require less aid and resist MITI's involvement.

The Japanese Government has encouraged the movement of people and resources into sectors with a potential for high growth and high productivity. Japan's long-term economic plans call for reducing the importance of the country's agricultural and manufacturing sectors, and expanding the economic role of the

Figure 40.—Long-Range Trends in Japanese Exports and Imports



SOURCE: I. Yamauchi, "Long-Range Strategic Planning in Japanese R and D," Futures, October 1983, p. 337

less energy-consuming, knowledge intensive service sectors. MITI sees this as following a long-term trend which is already evident in the United States. It encourages this shift by promoting productivity and quality control gains and reductions in labor, energy, and materials costs. PA is one means toward these ends.

Government Mechanisms

Industries currently targeted for development by the Government in Japan include computers, microelectronics and electronics, lasers, fiber optics, biotechnology, robotics, aerospace, and telecommunications.[6] The instruments of industrial development policy include:

- Visions.–These are Government-sponsored papers elaborating on current economic challenges facing Japan, and discussing strategies to meet these challenges. MITI writes these documents in collaboration with industry, labor, and political interest groups.' The visions are intended to aid business and Government agencies in strategic planning.
- *Government Assistance.* —The Japanese Government provides small amounts of financial support for R&D in private firms in order to serve as "a catalyst to stimulate private sector support of mutually agreed upon industrial development policy goals. "8 In general, the role of Japanese universities in research is much less significant than the role of industry, and much less prominent than that of their counterparts in the United States.
- *Rationalahation* Cartels.-In the late 1960's, in order to promote the development of internationally competitive firms in Japan, MITI guided the restructuring of Japanese industry by encouraging corporate mergers. (An increase in the number of new enterprises in Japan throughout the 1960's had resulted in strong domestic competition and a destabilization of Japanese industrial activity.) There continues to be a high level of merger activity toward the ends of enhancing management, maximizing the use of R&D, and facilitating the movement of capital among activities. Mergers are also motivated by the costs for large-scale investments in R&D and equipment.[9] It has recently been observed that companies are beginning to resist MITI-encouraged mergers as domestic competition in high-technology industries increases.
- *Tax Incentives.*— Special depreciation allowances exist for designated plant and equipment, in order to encourage development of targeted industries.
- *Monetary* Policies.–Throughout the postwar period, up until the early 1970's, the Japanese rationed credit. The Bank of Japan controlled the discount rate to influence macroeconomic decisions. "Typically, this ability was used to bias flows toward investment in productive infrastructure and capital-intensive manufacturing and away from consumer spending, housing and social infrastructure. "10 This control eroded in the 1970's as Japan joined the International Monetary Fund (IMF) and the Organization for Economic Cooperation and Development (OECD), and its capital market became more internationalized for a number of reasons.

Government Concern for Social Impacts of Technological Change

The Japanese Government has strong concerns about the social impacts of increased application of PA and other new technologies in the manufacturing sector. The Japanese Ministry of Labor released a report in May 1983

'Harold B. Malmgren and Jack Baranson, *Technology and Trade Policy: Issues and An Agenda for Action,* Washington, D. C.: October 1981; and Cabinet Council on Commerce and Trade, *An Assessment of U.S. Competitiveness in High Technology Industries,* U.S. Department of Commerce, ITA, February 1983,

7Jimmy Wheeler, Merit Janow, and Thomas Pepper, *Japanese Industrial Development Policies in the 1980's: Implications for U.S. Trade and Investment (New* York: Hudson Institute for the U.S. Department of State, October 1982).

*Ibid.

'MIT Center for Policy Alternatives, *National Support for Science and Technology: An* ***Examination*** *of* ***Foreign*** *Exchange, 1976.*

'"Wheeler, et al., op. cit., p. 7.

entitled, "Microelectronics and Its Impact on Labor." The report focuses on the employment effects of robots and microelectronic products and processes in Japanese firms. In response to the employment effects of changes in production technologies in Japanese industry, the Ministry of Labor has requested funds for the establishment of a "policy department" within the ministry. This department would monitor employment trends and allow the ministry to develop recommendations which would be considered in the development of national economic policy .11

Government Support to Industry

The Machine Tool Industry

A fundamental difference in the approach of the United States and Japan toward support of the machine tool industry is that U.S. programs have developed machinetool technology for military production purposes, while the Japanese Government encouraged broad industrial application of new machine-tool technology .12 The Japanese approach included government-funded research institutes, which allowed Japanese firms to spend lesson R&D than private U.S. firms generally considered necessary. Japanese research institutions were particularly responsive to the suggestions and experience of commercial end-users of the technology. 13

Japanese competitiveness in the low end of the world machine-tool market reflects the widespread application of the technology in the domestic economy. The Japanese Government provided technical information and assistance to small and medium-sized firms to encourage the application of machine-tool technology in industrial production. Government-sponsored technical centers provided cost-benefit estimates, customized software, and training to firms interested in numerically controlled (NC) machines. By reducing user uncertainty and costs, the Japanese have been able to develop both domestic and international markets for small NC machine tools.14

The Robot Industry

The Japan Industrial Robot Association.— In 1971, the Industrial Robot Roundtable was established; this was a precursor to the Japan Industrial Robot Association (JIRA). Formed in 1972, JIRA was initially a Government corporation financed by the proceeds of sports events sponsored by the machinery industry. In 1973, JIRA became an incorporated private association. This configuration allows MITI to deal with robot producers as a group. One-third of Japanese robot producers belong to JIRA, as do many Japanese and foreign robot users." JIRA's function is to promote the development of the robot industry through market surveys, the monitoring of technological advances, public relations, and development of new applications for robot systems. JIRA has been much more advanced in the collection and dissemination of information about robots and their uses than the association's counterpart in the United States, the Robotic Industries Association (RIA, formerly the Robot Institute of America). However, RIA is moving to bolster its information gathering and dissemination capabilities.

Japan Robot Leasing CO.–MITI has premeted the development and application of robot technology as one means of pursuing its overall strategies. However, the Japanese robot industry received little Government assistance until the late 1970's. In April 1980, MITI encouraged the establishment of the Japan Robot Leasing Co. (JAROL). JAROL was established in order to promote the use of industrial robots throughout the Japanese economy. The company leases robots primarily (90 per-

11 U.S. Embassy, Tokyo, Japan, unpublished summary of Japanese Ministry of Labor Report on Microelectronics and Its Impact on Labor, Aug. 5, 1983.

12see National Machine Tool Builders' Association, petition to the U.S. Department of Commerce under the National Security Clause for adjustment of imports of machine tools, Mar. 10, 1983; and the response from the Japan Machine Tool Builders' Association, June 27, 1983.

"National Academy of Engineering, *The Competitive Status of the Machine Tool Industry* (Washington, D. C.: National Academy Press, 1983), p. 31.

"Industry and Trade Strategies, unpublished contractor report for OTA.

15U.S. General Accounting Office, *Industrial Policy:* Case *Studies in the Japanese Experience,* Oct. 20, 1982.

25-452 0 - 84 - 23 : QL 3

cent) to small and medium-sized enterprises. JAROL is jointly owned by 24 major robot producers and 10 life insurance companies. The company initially received no Government funding, but now receives 60 percent of its financing from the Japan Development Bank in the form of low interest loans. The remaining 40 percent of JAROL financing comes from the Long-Term Credit Bank, the Industrial Bank of Japan, and various city banks. These favorable capital rates allow JAROL to lease robots at more favorable rates than ordinary leasing companies can offer. Neverthe less, other leasing companies and large robot vendors have also offered leases to robot users. JAROL received approval to extend leasing to companies abroad in the spring of 1983.[18]

Financial Incentives.—MITI has also encouraged the development of several fiscal and financial incentives to promote robot installation. Low interest loans are provided to small and medium-sized enterprises through the Small/Medium Business Finance Corp. (Chusho Kigyo Kinyo Koko) and the National Finance Corp. In addition, interest-free loans of up to 12 million yen ($51,000*) are provided by the Government to small and medium-sized enterprises for the modernization of manufacturing facilities.1[7] In order to promote robot applications for dangerous jobs, loans are available at 8 percent interest for the first 3 years and 8.3 percent for the remaining life of the loan. The Government budgeted 5.8 billion yen ($24.8 million) for these loans in 1980. In addition to ordinary depreciations, a special depreciation allowance was established in April 1980 for those firms installing industrial robots. A manufacturer who installs robots is permitted to depreciate 12.5 percent of the original purchase price in the first year, in addition to ordinary depreciation allowances. This may allow a firm to depreciate its robots as much as 52.5 percent during the first year. The depreciation rate was lowered to 10 percent for 1984 and 1985; the program is due to expire in 1985, though it may be renewed.18

Research and Development

In 1977, Japanese industry provided 65.7 percent of R&D funds in Japan, while the Government provided 16.1 percent and universities and other groups provided the remaining 18.2 percent. By contrast, in the United States, industry provided 43.8 percent, Government 51.1 percent, and universities 5.1 percent. In the Federal Republic of Germany, industry provided 55.6 percent, Government 41.5 percent, and 2.9 percent came from foreigners19 (see fig. 41).

The Japanese Government, like the United States and European governments, is modestly subsidizing R&D projects on robotics (table 72). MITI's Agency of Industrial Science and Technology has two laboratories in which a considerable amount of research on robotics is carried out—the Electro-Technical Laboratory and the Mechanical Engineering Laboratory. MITI has also developed cooperative projects among competitive robot manufacturers, who contribute researchers to the joint efforts. Public research has focused on theoretical problems that also tend to be relevant to applications-speed control, improved positioning accuracy, simplification and modularization of robots, sensory perception, and pattern recognition ability. These joint research efforts have sought to avoid duplication of research efforts by the producer firms. In addition, MITI, in conjunction with JIRA, spon-

"Paul Aron, *The Robot Scene in Japan: An Update*, Report #26, Daiwa Securities America, Inc., September 1983.

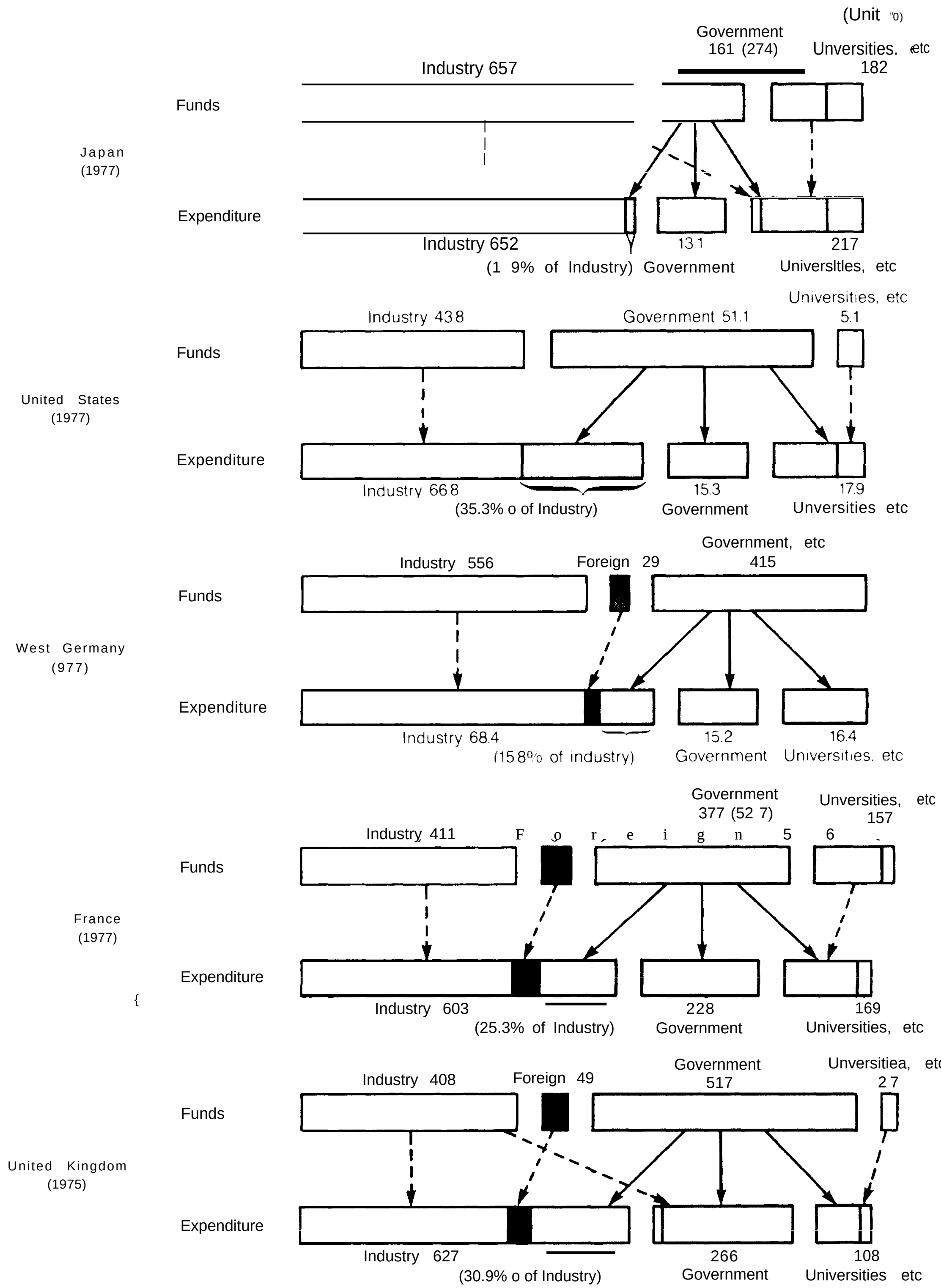
*Throughout this OTA report, foreign currency amounts are converted to their U.S. equivalent using foreign exchange rates in New York on Feb. 1, 1984, as cited in *The Wall Street Journal*, Feb. 2, 1984. Because the dollar was extraordinarily strong compared to foreign currencies at that time, the U.S. dollar equivalents given in this report are lower than they would be under more typical foreign exchange conditions. For reference, the exchange rates used are $1= 234.25 Japanese Yen, 0.7089 British Pounds, 1.2473 Canadian Dollars, 8.5425 French Francs, 7.853 Norwegian Krone, 8.1425 Swedish Krona, and 2.7925 West German Marks.

[17]William Rapp, Commercial Counselor, U.S. Embassy, Tokyo, personal communication, October 1983.

[18]GAO Industrial Policy Case Studies, op. cit., pp. 25-27; and Paul Aron, Daiwa Securities America, Inc., "Robots Revisited: One Year Later, " Report #25, July 28, 1981, p. 16 as reprinted in OTA Commissioned Background Papers to the *Exploratory Workshop on the Social Impacts of Robotics*, February 1982.

"'"Science and Technology White Paper '81 Released, " *Science and Technology in Japan*, January 1982, p. 9.

Figure 41.—Government/Industry/University Shares of R&D Funds and Expenditures



SOURCE Science and Technology in *Japan* January 1982 p 9

Table 73.—Government. Sponsored R&D Projects on Robotics in Japan

Project	Period	Sponsors
Industrial Robots Standardization Project	1974-81	AI ST/MITI[a]
Research Assembly Work	1976-78	Japan Small Auto Promotion Association
Research Project on System Design in Computer-Assisted Robot System Engineering	1976	Japan Machine Industrial Association
Laser Based Flexible Manufacturing System Technology Research Project	1977-84	MITI
Development & Research Project of Multiple Production System Adapting Super-High Lasers	1978-83	AIST
Research Project on Robotizing Cast Finishing Work	1978-83	Small Business Corporation
Research Project on Automatic & External Assembly of High-Rise Buildings	1978	Japan Machine Association
Technology Assessment of Industrial Robots	1980	Japan Industrial Technology Promotion Association

a AIsT_Agency of industrial science and Technology, MITI— Ministry of International Trade and Industry

SOURCE William Rapp, Commercial Counselor, U S Embassy, Tokyo, personal communication, Oct 13, 1983

sors the wide dissemination of resulting research data.[20]

Beginning in 1982. MITI was to Carry out a 7-year, 30 billion yen ($128 million) ro bot research program. It was intended to develop robots suitable for wider application, as well as to develop indigenous Japanese robot technology in order to reduce reliance on American and Western European innovations. The program was postponed for a time due to budgetary constraints, but work began in fiscal year 1983, and is still expected to be carried out over the envisioned 7-year period with full funding.[21]

Another of Japan's large-scale technology development schemes involves "developing complex production systems in which mechanical components for small-batch production of diversified products can be flexibly and rapidly produced from metallic materials in an integrated system. "[22] Under this scheme MITI provided 20 percent [13 billion yen ($55.5 million) over fiscal years 1977-83] of the funding for the development of a Flexible Manufacturing Complex Utilizing Lasers.[23] The program did not finish on schedule, and was extended through 1984 with an extra 1 billion yen ($4.3 million).[24] The project had to be scaled down because extensive reliance on one large laser did not prove practical. The program has since incorporated more conventional applications. These applications, however, are not being used widely in the commercial sector for technical reasons. The project has become some thing of a "showcase" for advanced Japanese technology. Other projects aiming at computerized manufacturing integration are also underway in Japan, building on machine tool, robot, and computer research efforts.

[20] Paul Aron, Report #25, op. cit., p. 17; and Paul Aron, Report #26, op. cit., pp. 26-27.
[21] Paul Aron, Report #26, op. cit.
[22] GAO Industrial Policy Case Studies, op. cit., p. 9.
[23] U.S. Department of Commerce, International Trade Administration, *High Technology Industries: Profiles* and *Outlooks, The Robotics Industry,* April 1983, p. 25.
[24] Federal Broadcast Information Service and GAO Industrial Policy Case Studies, op. cit., p. 28.

West Germany

Direct Government Role

Government expenditures as a percentage of gross national product in West Germany are relatively high compared to other Europe an nations. The country has a highly developed social welfare system providing generous health, unemployment, and social security benefits; the system also permits a degree of worker participation in business management.[25] However, West Germany has no sharply defined industrial policy. It is similar to the United States in that Government support for industry is more or less decentralized, and there is substantial support at the State level. The Lander (States) can give housing grants to workers, grant land, and provide credit guarantees to attract new industries or preserve old ones.[26]

Since the oil crises of the 1970's, Government intervention in the German economy has increased in the form of direct subsidies, tax relief, special depreciation allowances, and preferential interest rates. The Government guarantees risk-capital loans to private business through Risk Financing Associations, which are made up of private banks. The Deutsche Wagnis Finanzierungs Gesellschaft (DWFG), formed in 1975, is a financing consortium owned by 28 large commercial banks and backed by the Federal Government to pro tide venture capital in the FRG.[27] The Government has also developed fiscal policy incentives to promote innovation, as well as an information network on new patents to ensure that they are effectively applied.

The Government provides over 90 percent of total R&D spending in Germany, although it provides only limited direction for research. The Ministry of Research and Technology (Bundesministerium fur Forschung und Technologies, or BMFT) is the coordinating agency for technology policy and the major provider of R&D funds. BMFT is concerned with general macroeconomic policy, promotion of inrm vation, and the health of small and medium-sized businesses. The Science Council, or Wissenschaftstrat, determines the objectives and priorities of R&D policy and makes budget allocations and recommendations. The Council is comprised of a board of experts from the Government [both the Bund (Federal) and Lander (State)], academia, industry, and the German research institutes. Although the recommendations of the Council are not binding, they carry considerable influence. The Wissenschaftstrat embodies the emphasis that German society places on scientific endeavors.[28]

Government Concern for the Social Impacts of Technological Change

Government-labor-industry relations in regard to encouraging and adapting to technological change are particularly good in West Germany. A well-developed communication network has been created between industry and Government through "quasi-public, semiautonomous" research institutes and a system of advisory councils.[29] The foundation for concerted action between labor unions and employers' associations on the one hand, and Federal, State, and local government officials on the other, was established in 1966 with the Stability and Growth Act. Regular consultation between Government ministers and labor union officials on matters concerning industrial policy, income policy, and international competition and trade policy has evoked a social consensus.[30] The potential Social impacts of technological change (particularly those that may take place within the workplace) have been part of the political agenda. Throughout the 1970's, following the German Social Democratic Party's rise to power, a large number of occupational safety and health measures were enacted by the Federal Republic of Germany. See chapter 5 for a more detailed discussion of relevant legislation and the Humanization of Work Program, which is a central feature of Government action to address the social impacts of technological change.

[25] MIT Center for Policy Alternatives, *National Support for Science and Technology An Examination of Foreign Exchange, 1976.*

[26] Wolfgang Hager, *National Industrial Strategies and the World Economy,* William Diebold and John Pinder (eds.), Atlantic Institute for International Affairs, Research Series, vol. 6, 1982, p. 241.

[27] 'Venture Capital Struggles to Get Off the Ground,' *Financial Times of London,* Feb. 11, 1983, p. 1c.

[28] Malmgren, op. cit.; and Massachusetts Institute of Technology, op. cit., pp. 14-23.

[29] Malmgren, op. cit., p. 39.

[30] *International Trade, Industrial Policies, and the Future of American Industry,* The Labor Industry Coalition for International Trade, April 1983, p. 30.

Government Support to Industry

Government Commitment to Small and Medium-Sized Firms

In the late 1970's, the Federal Republic of Germany initiated a number of programs to promote research, development, and innovation in small and medium-sized enterprises. The directing of technology policy toward these companies represents a growing awareness in the West German Government of the importance of such firms for innovation, growth, and employment.sl These programs include funding for scientific and technical persoNNel, external contract research, and innovation consultancy.

Direct support of small and medium-sized enterprises by the BMFT has been rising. This reflects expansion of BMFT programs to include electronics, computer applications, and humanization of the working environment. In addition, the BMFT has increased its efforts to make smaller firms more aware of the Government support available to them. The Ministry for Economic Affairs (Bundesrninisterium fur Wirtschaft, or BMWi) assists small and medium-sized firms indirectly by supporting the Federation of Industrial Cooperative Research Associations (Arbeitsgemeinschaft Industrieller Forschungsvereinigungen, or A IF). A IF **consists** of more than 80 individual research associations which aid the smaller firms through publicity, research seminars, and technical advisory services. Another program administered by BMWi provides subsidies for 30 percent of the total cost [up to DM120,000 ($43,000)] of contract research placed by a small or medium-sized firm with a public or private research institution. The program is funded, however, by BMFT.[32]

The largest current program designed to support small and medium-sized firms is the "Program of Grants Towards the Costs of R&D Personnel. " The program is administered by AIF on behalf of BMWi. It offers grants of 25 percent of gross wages and salaries, and 40 percent of the expenses of R&D Personnel.[33] This program provided DM1.1 billion ($394 million) to West German industry between 1981 and 1983. Its objective is to nurture industrial innovation by providing subsidies for scientific and technical personnel. BMFT also provides free innovation counseling to small and medium-sized firms in several offices throughout the country. In addition, there is a Technology Center in Berlin which is linked to the German Engineers Association (VDI) to promote the diffusion of technology. This center provides information on the adoption of microelectronics and other technologies, assists firms in applying for R&D support from Federal agencies, and carries out studies on new technologies.[34]

Research and Development

The Ministry of Research and Technology (BMFT).–The Ministry supports approximately 6,000 projects in the form of grants to research societies such as the Max Planck or Fraunhofer institutes, national laboratories, and individual research groups in universities and industry. The 1983 budget breakdown is shown in table 73. It is expected that R&D funding will increase for biotechnology, information science, microelectronics, robotics, environmental protection, climatology, and public health.[96]

In 1980, BMFT established a program, called "Fertigungstechnik," which supports the development of advanced manufacturing technologies. The program is directed at R&D efforts in small and medium-sized firms in order to provide a high level of technological capacity in West Germany. In particular, it provides Government funds for risky R&D projects with high imovative potential.[98] The

[91]" Impacts of Government Incentives Towards Industrial Innotation, " Meyer-Krahmer, Gielow and Kuntze, *Research Policy,* June 1983, pp. 153-154.

[32]OECD, *Innovation in Small and Medium Enterprises,* Paris, 1970, p. 133.

"Labor Industry Coalition, op. cit.; and Dietmar Frenzel, Counselor, Science and Technology, Embassy of the Federal Republic of Germany, personal communication, Feb. 23, 1984.

[34]0ECD, op. cit.

"U.S. Cable Traffic, American Embassy, Bonn, June 27, 1983, Robert Morris, Counselor for Scientific & Technological Affairs.

[3]6Ibid.

Table 74.—Budget of the BMFT[a]

Category of expenditure	Millions of dollars
General (societies and institutes). . .	$ 217
Science and technology research	578
Information technologies ., ...	243
Energy	1,052
Space, oceanography, transport . . .	514
Total	$2,604

a In U S dollars converted at $1 DM 27915

SOURCE Robert Morris, Counselor for Scientific and Technological Affairs U S Embassy Bonn FRG

program distributes funds in the form of grants or loans for private, basic R&D, and private or commercial R&D that includes work on the commercial application of existing technologies. There is also Government-funded R&D activity in Government facilities and State-owned firms aimed at developing new technologies. The program spent DM44.1 million ($15.79 million) in 1980, and DM58.5 million ($20.95 million) in 1981, and planned significant increases for subsequent years. Due to budget cuts, however, only DM45.7 million ($16.37 million) were available in 1982, and only DM38.5 million ($13.79 million) in 1983.[37]

The Government is also involved in monitoring foreign technological developments, fostering Government-industry cooperation, establishing national standards, providing international educational exchange programs, and export promotion.

West German-Norwegian Collaboration

The Fraunhofer Institute for Production Systems and Design Technology (IPK) and three other West German industrial research institutes have been involved in a joint Government-sponsored research effort with the Norwegians for the last 2 years. The effort arose out of negotiations securing West German rights to drill for Norwegian oil, and it involves technical universities and industrial firms in both countries. The Norwegians and West Germans are developing an advanced production system (APS) for CAD applications in mechanical engineering. APS would integrate into a modular system existing programs for geometric modeling, NC machine tool programing, and process planning. The long-term goal is to develop a state of the art, computer-integrated manufacturing system to be marketed by the firms involved. The program is built around an advanced geometrical modeling system, which is designed to interface with all elements of a manufacturing system from design to assembly. APS is similar to the IPAD and ICAM projects being funded by the National Aeronautics and Space Administration and the U.S. Department of Defense (see ch. 8). The APS program, initiated in 1981, had an initial joint funding commitment of $45 million.[88]

R&D Tax Credit

The West Germans have instituted a special tax credit to promote R&D. A 40 percent depreciation allowance is granted for movable equipment utilized exclusively for R&D. A 15 percent depreciation allowance is available for fixed plant equipment which is utilized two-thirds of the time for R&D. Another 10 percent depreciation allowance is available for the construction cost of buildings of which at least one-third is devoted to R&D.[39]

37Robert .Morris, U.S. Embassy, Bonn, FRG, personal communication, Aug. 4, 1983.

‘*Eugene Merchant, Metcut Associates, personal communication; and *American Metal Market/Metal Working News,* “CAD/CAM Systems m Europe, ” Apr. 11, 1983.

“R. G. Morris, Counselor for Scientific and Technological Affairs, American Embassy, Bonn, personal communication, Aug. 4, 1983.

Sweden

Direct Government Role

The Swedish Government has traditionally played a very strong role in the Swedish economy. The Government owns 5 percent of Swedish industry, primary in mining, public utilities, transportation, and communications.[40] Exports and imports accounted for an average 30 percent share of GNP between 1975 and 1980 in Sweden. Principal producers for export include shipbuilding, mining, steel, and forest industries. Nearly half of all Swedish industrial products are sold abroad, while almost all of the Swedish energy supply is imported. Machinery and mechanical equipment also make up a large share of Swedish imports. Given Sweden's dependence on external trade, international competitiveness is vital to its economy.

In the 1970's, Sweden was faced with serious structural economic problems. With what was traditionally an export-led economy, the country began to encounter increased competition in its major export markets. The oil price increases and high wage costs, combined with shrinking world demand and growing international competition, caused Sweden's major export sectors to deteriorate. The rise in value of the Swedish Crown as a result of the European Currency Agreement also hurt Swedish exports. The most immediate aim of economic policy in Sweden today is to lower relative prices of Swedish industrial goods on the world market, to regain Swedish market shares in both the export and domestic markets.[41]

The Swedish Government recognizes that production of PA equipment may be strategically desirable, and it is concerned about a possible shortage of skilled labor. Historically, Swedish Government outlays in support of active manpower policies have been relatively high. The Swedish "Active Labor Market" policy includes early and mandatory notification of plant closings, a virtual State monopoly on employment services, and extensive career counseling and support for training programs."

Sweden's unique political and cultural context favors certain types of innovative programs, while it makes comparisons of Government policy with other countries particularly difficult.

Government Support to Industry

According to an official of the Royal Swedish Academy of Engineering Sciences:

> The ability of Sweden to compete on the world market for manufactured products will increasingly depend on the ability and willingness of Swedish industrial firms to invest in and use the new generation of manufacturing technologies.[43]

The National Industrial Board has also stressed the need to promote structural economic change in Sweden in response to changes in world markets and Sweden's deteriorating competitiveness. It has recommended three major types of policy measures. The first promotes development of production resources through investments in technology development and acquisition of capital stock in sectors that are expected to be competitive in the long term. The second emphasizes selection or targeting of those areas which are expected to produce the highest yields in the future. Finally, the Board stresses that the distribution of labor and capital in the production system may be strongly influenced by political concerns.

40 The Swedish Institute, "Fact Sheets on Sweden," September 1980.

[41] *Swedish Industry Up to 1990: Analysis and Policy Propsals,* National Industrial Board of Sweden, 1981 Autumn Report, pp. 84-85.

[42] M. Bendick, Jr., "The Swedish 'Active Labor Market' Approach to Reemploying Workers Dislocated by Economic Change," The Urban Institute, Washington, D. C., March 1983.

[43] Hans Anderson, Project Manager, Royal Swedish Academy of Engineering Sciences, personal communication, May 19, 1983.

The Swedish Committee on Labor Market Education and Training Within Industry

With respect to labor development, the Swedish Committee on Labor Market Education and Raining Within Industry (KAFU) is currently studying Swedish needs for skilled labor. It is exploring whether or not the education and training system is supporting those with "a weak position in the labor market, " and whether or not the Government should take action which would put personnel training directly within companies. Despite the active manpower policies, unemployment is still high, and there is some concern that Government-funded training programs are becoming just a "holding pen" for otherwise unemployed workers. 44 The National Industrial Bored is also concerned about the supply of skilled labor and relevant Government responses.

The Swedish Commission on Computers and Electronics

In April 1981, the Swedish Commission on Computers and Electronics (Data-och Elektronikkomitten, or DEK) reported to the Minister of Industry on the promotion of PA in Sweden. According to DEK, large opportunities for improving productivity lie in:

> . . . optimally interconnecting various processes into computer-integrated manufacturing systems. In the engineering industries, and especially those subjected to strong international competition [automotive industry, computers and telecommunications, consumer electronics, household appliances, etc.), systems integration is regarded as the key to survival in the 1980's.45

CAD.–The Swedish Government has placed a high priority on promoting the development of CAD. In 1982, DEK introduced new legislation which included the allocation of 14 million Skr ($1.7 million) during 1982/83 in part for the formation of three CAD centers.[48] A DEK report lists the following motives for promoting the diffusion of these technologies throughout the economy: 1) to increase productivity and, thereby, profitability; 2) to improve the conditions of work; 3) to improve precision and tooling complexity; 4) to acquire experience with new technologies; and 5) to reduce consumption of energy and raw materials.[47]

DEK recommended that the Swedish Government coordinate activities promoting new production technologies, and, in particular, that it promote long-term technology development and skills development at technical facilities. It recommended enlarging the vocational training program at the Swedish Institute for Corporate Development (SIFU), and establishing a traini.ng program for vocational instructors on computer-based production technologies.[48]

The Program for Diffusion of Industrial Robots and Computer Control-led Production Techniques. -On April 1, 1983, DEK announced the Program for Diffusion of Industrial Robots and Computer Controlled Production Techniques. In order to promote wider use of PA in small and medium-sized firms that have little or no familiarity with PA, DEK proposed the following measures:

1. An information campaign revolving around the 14th Annual International Symposium on Industrial Robots (ISIR), which will be held in Stockholm in October 1984.
2. Support for production technology development projects.
3. Educational programs for project personnel.
4. Development of a consultancy program.
5. Regional educational programs which

[44] Bendick, op. cit.

[45] *The Promotion of Robotics and CAD/CAM in Sweden,* report from the Computers and Electronics Commission, Ministry of Industry, LiberForlag, Stockholm, 1981, p. 1.

[46] Jan Carlsson, Computers and Electronics Commission, in a presentation at the IBM workshops: *Automation in Manufacturing: Effects on Productivity, Employment and Worklife;* Jafalla plant, Stockholm, Mar. 30-31, 1982, p. 24.

"Computers and Electronics Commission Report on the Promotion of CAD/CAM in Sweden, op. cit., p. 18.

[48] Ibid.

would include demonstration programs, including robot-assisted lathes and automated materials handling, robot welding and automated materials handling, and flexible automated machine loading.

To further international recognition of Swedish PA industries, I SIR will include visits to producer and user plants by foreign participants. DEK has also proposed a microelectronics campaign in Sweden. Finally, DEK has considered establishing direct support for the Swedish PA industry based on Japanese and British models. Because it found problems with establishing similar support mechanisms in Sweden, DEK did not take a firm position on this issue.49

The Swedish Board for Technical Development (STU)

The Swedish Board for Technical Development (STU) operates under the auspices of the Swedish Ministry of Industry, and provides funding for advanced R&D in universities, re search laboratories, and industry. Between 1972 and 1979, STU funding for robotics and CAD amounted to approximately 25 million Skr ($3.07 million) .'"

Total STU support for R&D in engineering industries is expected to increase considerably, to 260 million Skr ($31.93 million) for the period 1980/81-1984/85.[61] Of this amount, 14 million Skr ($1.72 million) will go toward CAD and CAM R&D. Long-term projects are also planned for adaptive control of machine tools and industrial robots, and a 10 million Skr ($1.23 million), 4-year CAD joint venture project is planned between Saab-Scania, STU, and two universities.[52] Saab-Scania will eventually invest about 3 million Skr ($370,000) toward the commercial development of this CAD 80 system.[53] STU and the Swedish Association of Mechanical and Electrical Industries have aeneed to sponsor a 5-year CAD and CAM research program. Their agreement calls for a commitment of 46 million Skr ($5.65 million) and 48 million Skr ($5.89 million), for STU and the association, respectively .54

[49] *Teknikspridningsprogram For Industrirobotar och Datorstodd Produktionsteknik*, IndustriDepartmentet, Data-och elektronikkommitten, DSI 1983:6.

'°Computers and Electronics Commission Report on the Promotion of CAD/CAM in Sweden, op. cit., p. 30.

[61] Carlsson, op. cit., p. 25.

'* Ibid., and Computers and Electronics Commission Report on the Promotion of CAD/CAM in Sweden, op. cit.

"Computers and Electronics Commission Report on the Promotion of CAD/CAM in Sweden, op. cit., pp. 30-31.

"Computers and Electronics Commission Report on the Promotion of CAD/CAM in Sweden, op. cit., p. 31, and Carlsson, op. cit., p. 25.

France

The French Government has traditionally played a large role in the coordination, funding, and direction of the French economy since Jean Baptiste Colbert founded the Academy of Sciences in 1666. French Governments since have changed the scope and nature of that involvement but the traditional mechanisms used by Government have changed very little.

Since World War II, information technology, including PA, has been of major interest to the French Government and therefore to the French industrial and educational communities. Funding commitments, research, and industrial production for information technologies have been directed toward two major goals: 1) world recognition of France as a leading manufacturer of high technology products, and 2) the development of information technology-based systems and patterns of communication which could help preserve and develop French culture and society.

Recently, France's high technology push gained new strength. The last French Presidential election (1981) marked the first time science and technology was a political issue.[65] Indeed, all candidates had indicated that increased funding for R&D was one of their goals. Before losing to Mr. Mitterrand, Mr. d'Estaing had designed a plan for increasing real Government R&D funding 8 percent per year for 5 years beginning in 1980. When Mr. Mitterrand was elected, he more than doubled that goal. During 1982-85, the Mitterrand government had planned to increase R&D expenditures 17.8 percent with the objective of spending 2.5 percent of French gross national product on R&D by 1985.[56]

Mitterrand's emphasis on increasing R&D spending was part of an ambitious industrial policy for France which included employment and education policies as well as planned market programs in several areas of high technology, including PA.[57] The programs were all de signed around the Socialist principles of decentralization, democratization, humanism, and volunteerism. For example, researchers are thought to have a social and economic function which capitalism has inhibited. More transfer of technology between industry and Government is seen as one way of enabling such functions to be undertaken and the nationalization of industries is considered to be the mechanism for achieving social and economic research.

Several key high-technology industries, including computers, telecommunications equipment, aircraft, and electronics have been nationalized. This is in addition to the previously nationalized automaker Renault, oil company Elf Aquitaine, and aircraft manufacturer Aerospatiale. Today, about threefourths of all industrial R&D spending takes place in nationalized companies.[58] For information technology, including PA, the figure is considerably higher as almost every major industrial actor in the area has been reorganized to reflect a majority Government ownership interest.

Mitterrand has two high-technology plans for PA. (The plans both had roots in the d'Estaing government, but were reorganized by Mitterrand to reflect a stronger Government role and increased funding.) The first, published in April 1982,[69] includes plans for robotics, machine tools, and numerical control devices. It is often referred to as the Filiere Robotique.* The second technology plan for PA was published by the Ministry of Research and Industry in July 1982.[60] This is referred to as the Filiere Electronique and includes aid for CAD and CIM.

Filiere Robotique

Three goals have been announced for the Filiere Robotique: productivity improvements, better working conditions, and economic gain from the sale of PA equipment. The last goal is of particular interest to the French. Although Renault is France's largest manufacturer of PA equipment, representing 50 percent of France's industrial commitment to PA research, France still imports more than 50 percent of its PA consumption.[G']

The three goals of the Filiere Robotique are to be implemented through programs of increased R&D in robotics, automation, mechanics, electronics, hydraulics, and software; increased production of PA components and materials; diffusion of automation technologies; and the use of PA in a variety of economic sectors. In 1981, total French Government assistance to the Filiere Robotique amounted to 251 million francs ($29.4 million), of which 91 million francs ($1o.7 million) went to R&D and 160 million ($18.7 million) to man-

[b]Pierre Aigrain, "The French Experience in High Technology, " Center for Strategic and International Studies, Georgetown University, Washington, D. C., p. 2

'Interview with M. Morel, Conseiller Technique du President de la Republique, June 20, 1983.

"''French Technology Preparing for the 21st Century, "*Scientific American,* November 1982.

[a]Ibid.

"*L 'Utilisation de la Robotique Dans la Production et ses Perspectives D'Avenir*, Conseil Economique et Social, 2 Avril 1982.

*A "filiere" in France is a targeted industry grouping or other goal around which a Government plan for R&D funding, production investment, education, and dissemination assistance has been developed. There are six filieres in France today; robotics, electronics, energy, biotechnology, working conditions, and cooperation with developing countries.

[60]*Filiere Electronique, Plan du Dossier,* Ministre de la Recherche et de l'Industrie, 28 Juillet 1982.

[61]Ibid.

ufacturer assistance. Plans for 1982 included increasing the R&D budget by 29 percent and the aid to industry by 104 percent.[62]

Within the Filiere Robotique there is a separate plan for machine tools. Le Plan Machine Outil is a 3-year venture in which the French Government expects to spend 2.3 billion francs ($269 million) from 1983-85. The plan's main objective is to double production of French machine tools within 3 years. Key elements of this effort, according to the French Government's published plan, were the nationalization of C. G. E., Saint-Gobain, and Thomson, and majority Government participation in Matra and Dassault. The French Government also expressed interest in reorganizing the commercial activities of small robotics material manufacturers,[63] but no course of action for such was detailed.

There are three Government ministries and nine separate agencies involved in the Filiere Robotique. The defense ministry, through its office of Space Research and Studies, has a project (Projet SOLARIS) to study the use of robots in space. The ministry of industry and research has 26 projects ranging from the use of robotics for the handicapped to their use in nuclear reactor inspection. Involved in these projects are the National Scientific Research Center (CNRS), the Institute for Computer Sciences and Automation Research (INRIA), the Data Processing Agency (ADI), the National Agency to Valorize (commercialize) Research (ANVAR), and the Atomic Energy Commission (CEA). The education ministry has a two-part research program which includes both the French university system and the Grandes Ecoles. In total, the French estimate that these projects involve the equivalent of between 250 and 300 researchers."'

The industrial component of this research activity includes collective centers (both trade associations and quasi-Govemmment groups) formed around machine tools, textiles, petroleum, and other products. In addition, research is being carried out in both nationalized corporations such as Renault, and in private firms like Telemecanique.[os]

A related program is being carried out by the Agency for the Development of Automated Production (ADEPA) of the Ministry of Industry to promote the application of CNC machine tools, robots, flexible machining cells, and flexible manufacturing systems in small and medium-sized firms. Representatives from ADEPA identify possible users of PA equipment and invite the firms to participate in a 2-year trial use of PA in their production facility. Firms that agree are given equipment to use for 2 years and technical assistance from ADEPA. At the end of the 2-year trial period, the firm has the option of paying for the machinery (less 2 years' depreciation charges) or returning it and paying only the depreciation cost. Of the first 100 companies that participated, almost none returned the equipment.[oe]

Filiere Electronique

This program's stated long-term goal was to place France on a technological level in electronics equal to that of the United States and Japan. The infusion of 140 billion francs ($16.4 billion) in R&D funds over the 5 years following 1982 was expected to produce a surplus balance of trade in information technology, create 80,000 new jobs, assure mastery of information technologies, and accelerate the production of information technology products by 3 to 9 percent each year. Eight areas of achievement were outlined:

- computer-aided circuit design for very large scale integrated circuits,
- computer-aided design and manufacturing,
- artificial intelligence,
- computer graphics,
- peripherals,

'*Ibid.
[s]Ibid.
"Ibid.

"Ibid.
'Eugene Merchant, personal communication; and *An Assessment of the Industn"al Energy Conservation Program for the Pulp aud Paper and General Manufacturing Industn"es,* National Research Council, National Academy Press, 1983, p. 14.

- computer-aided translation, computer-aided instruction, and
- consumer electronics.

In January 1983, the Ministry published its plan of action.[67] In the of computer-tided design and manufacturing, an evaluative group was assembled to design research, development, and production plans. The group's members included the Direction Generale des Telecommunications (part of the national telephone concern), the Delegation Generale aux Armements (part of the Ministry of Defense), DEILI (Direction des Industries Electroniques et de l 'Informatique; part of the Ministry of Industry and Research), ADI, CNRS, and INRIA.

This group, along with several others formed in the other areas of the Filiere, created Le Projet Cadre, designed to pursue four areas of inquiry: scientific calculation, CAD, management of information technology product production, and software development for PA.68 The implementation plans for this project were not specified.

Implementation of the Filieres Electronique and Robotique

The public announcements concerning the electronics and robotics sectors programs made in the year or so following the implementation of the programs (early 1982) became at once more ambitious and less specific, and were accompanied by reduced funding. Funding in 1982 for the electronics sector amounted to about 6 billion francs and 1983 expenditures were expected to be approximately 8 billion francs-far short of the proposed 28 billion each year.[69]

Funding problems for the Mitterrand government have been pervasive, and the plans for a vast effort in PA have suffered significantly as a result. In discussions with several French Government agencies involved in PA in the summer of 1983, it was revealed that the average agency cutback for 1983-84 was about 20 percent from levels projected in 1981; this not only virtually eliminates the increases desired by the Mitterrand government over that spent by d'Estaing, but for several agencies requires operating levels that are lower than those of the last administration. This reduced spending was not accompanied by a consolidation or reduction in the number of PA projects. The entirety of the robotics and electronics sectors plans are intact. The result may be that PA projects are funded at inconsequential levels.

several other problems were encountered by the Mitterrand government in its effort to mobilize the country's PA resources. Substantial difficulty was encountered with nationalization, apparently due to a large philosophical divergence between executives among the targets of nationalization and the former Minister of Research and Industry.

Even without the financial constraints on French PA activities, there would still be serious manpower problems. The number of pee ple with Level I qualifications (approximately equal to an American Ph. D.) in information technology is expected to fall short of needs by 70,000 for the period 1981-90 in France. In the French context, this number is quite large; in 1979 it was estimated that 105,000 scientists and engineers were actively involved in all aspects of French science (energy, pharmaceuticals, mechanics, etc., as well as information technology) .70

[67] Ministre de la Recherche et de 1'Industrie, *Programme Mobilisateur, 20* Janvier 1983.

"Ibid., p. 6.

"See for example, *A. F. P. Sciences, No.* 341, Jan. 17, 1983, pp. 1-4.

'"Jean-Pierre Letouzey, Scientific Mission, Embassy of France, *Statement for the American Association for the Acfvancement of Sciences,* Mar. 24, 1983.

United Kingdom

Direct Government Role

The British Government, as a rule, does not actively intervene in the national economy as much as the Japanese or French Governments. The Government provides funds for R&D in risky areas and in areas with commercial potential. The Department of Trade and Industry (DTI) has recently developed a set of schemes including support for R&D, feasibility studies, capital equipment investments, and demonstration programs, in order to encourage the implementation of PA in the United Kingdom.

Since World War II, the British Government has been spending sizable amounts in support of science and technology; however, the numerous British economic and technology policies have lacked a clear objective and have suffered from poor public-private sector cooperation. Overall, the British machine tool and robot industries are small, but the CAD and CAM software industry is strong. Financial support for "high-technology" industries has not been as great as support for the auto, shipbuilding, and steel industries. Since the latter half of the 1970's, DTI programs have focused more on commercial exploitation of new inventions than on R&D, per se, although mechanisms and funding have been provided to support research where private companies have been reluctant to invest. These programs have not always resulted in commercially successful products, the most notable example being the Concorde.[71]

In the late 1970's the Labour government investigated PA. The two most noteworthy efforts yielded the ACARD report (named after the Advisory Council for Applied Research and Development, which is responsible for advising Government ministers) and the Ingersoll report. The ACARD report documents a working group's effort "to consider the effectiveness of technology transfer and the adequacy of current research and development on joining and assembly in relation to the needs of U.K. industry, and to make recommendations."[72] It noted that the United Kingdom had many fewer robots in place than other industrialized countries, and it recommended accelerated application of PA.

DTI's predecessor, the Department of Industry, commissioned a report on industrial robots from Ingersoll Engineers in 1979. The report "outlined the scope for, and importance of, robotics, identified problems facing the take up of robots, and put forward a national robot programme, which foreshadowed the actual programmes followed by the Department of Industry and the Science and Engineering Research Council." Initially, under the Thatcher government, it appeared as though the initiative in PA would be left up to private industry. However, at the "Automan 1981" Conference, Prime Minister Thatcher, in a speech endorsing robotics, indicated the Government's willingness to take action to promote the use of PA in British industry.[73]

DTI also oversees an elaborate network of agencies encouraging R&D and the transfer of technology throughout the economy. These include the Research and Development Requirements Boards, Industrial Research Establishments, Industrial Research Associations, and the British Technology Group (BTG).

BTG was formed in 1981 as an independent public corporation set up to promote the development and application of new technology. It includes the former National Research Development Council (NRDC) and the National Enterprise Board (NEB). BTG attempts to ensure the commercial utilization of the results

[71] Malmgren, op. cit., quoting Gilpin, p. 51; and David A. Brown, "Funding Dispute Snags British Program," *Aviation Week and Space Technology,* Apr. 18, 1983, p. 65.

[72] The report, entitled *Joining and Assembly: The Impact of Robots and Automation,* was released in October 1979. James Fleck, University of Aston, U. K., personal communication.

[73] James Fleck, personal communication.

of Government-sponsored research and provides capital to private business in order to encourage innovations. While BTG is under the auspices of the Secretary of State for Trade and Industry, its day-to-day activities are free of Government intervention. BTG receives its operating income from royalties, licensing, and other forms of reimbursement. It also receives financing from DTI which it repays with interest.

In early 1983, in part as a response to Japanese and American efforts to develop "fifth generation' computers, the British set up a national advanced technology research program. A committee chartered by the Minister for Information Technology and headed by John Alvey recommended a Government/industry/university cooperative program aimed at four main areas: very large scale integrated electronic components, software engineering, man/dmachine interfaces, and intelligent knowledge-based systems.

The Government will pay half of the cost of this collaborative research effort in industry, and 100 percent of research costs in universities. The "Alvey Report" estimated that academic institutions should carry out 50 million ($70.5 million) of research over 5 years, and industry 300 million ($423 million), resulting in a Government expenditure of approximately 200 million ($282 million) .74

Government Support to Industry

Research and Development

Support for Industry R&D.—A series of programs was set up in the late 1970's in order to promote the diffusion of technology throughout the economy; these included the Microelectronics Application Program (MAP), the Manufacturing Advisory Service (MAS), and a Robotics Advisory Service (RAS). MAS was established in October 1977 in order to increase the competitiveness of manufacturing firms by offering subsidized consulting services. Its budget in 1982 was -# 9.25 million ($13 million), with 80 percent going to small and medium-sized enterprises.[76] The RAS is operated by the Production Engineering Research Association (PERA), as is MAS. RAS offers an information service, a demonstration center, and subsidization of feasibility studies to assist small businesses in applying robots to production processes. DTI highlighted these programs as part of a campaign declaring 1983 "Quality Assurance Year. " The intention is to make industry more aware of the Government financial support available to implement robots, flexible machining systems, CAD, and microelectronics. The year 1982 was declared "Information Technology Year," and relevant demonstration programs, public seminars, and conferences were held.[76]

The Science and Engineering Research Council .–The Science and Engineering research council (SERC) is one of five research councils funded by the Department of Education and Science. The function of the councils is to promote and sponsor basic research in universities and in Government. SERC'S "Robotics Initiative" was announced in July 1980. It called for SERC to provide ' 2.5 million ($3.53 million) for the study of future generations of robots. The program has already resulted in the development at Oxford University of a laser scanning device for arc-welding applications.

Department of Trade and Industry Special Programs

The Robot Support Program. -DTI initiated the Robot Support Program in April 1981 in response to the recommendations of the ACARD and Ingersoll reports. The program was originally funded at 10 million ($14.11 million) in three areas: 1) Support for feasibility studies in order to allow a company to determine if robots would be cost-effective. A company may choose a consultant from DTI list of approved consultants for the feasibility study. The Department *will* then pay 50 per-

[74]The Department of Trade and Industry, "A Programme for Advanced Information Technology, " The Report of the Alvey Committee (London: Her Majesty's Stationery Office, 1982).

[76]OECD, *Innovation in Small and Medium Enterprises,* Paris, 1970.

[76]James Fleck, personal communication.

cent of the cost of the study for up to 15 person-days. 2) Support for robot purchase and installation. The Government will support up to one-third of the cost of the robot and associated capital equipment. Development costs such as the labor cost for development engineers, etc., and the cost of new tooling are covered by grants of up to one-third. The Department will also provide support for lease=financed robots. 3) Support for companies seeking to develop or manufacture robots. Grants are available for up to one-third of the costs of "projects involving the design and development by U.K. manufacturers of new industrial robots and associated equipment up to the point of commercial production. "[77]

Despite these ambitious product and process development schemes, many companies applying for such funds have been turned down by banks with strict lending criteria, even though the Government guarantees 80 percent of the loans. Bank restraint has been attributed to the perception that many applicants show insufficient commitment to their projects. It is thought that as many as one in five of the participants may fail.[78] In addition, under the consultancy portion of the program, many firms decide not to implement PA because the new technologies do not appear to be the most cost effective manner of improving their production processes. Furthermore, the approved list of consultants provide by DTI includes a disclaimer as to the competence of the consultants.

By April 1983, the following funds had been committed under the Robot Support Program:

- 92 company installations . . 6.5 million ($9.17 million)
- 25 robot manufacturers . . 2.7 million ($3.81 million)
- 69 consultancies . 129,000 ($182,000)

DTI has been disappointed by the low level of interest from industry as measured by applications for funding. While the initial allocation of funds to the program may ultimately be spent, the future of the program is uncertain. However, robots will continue to be supported under a Flexible Manufacturing System Program (see below).[79]

Other Programs.—Similar programs have been set up under an umbrella "support for innovation" policy. These programs have been devised to promote CAD; computer-aided design, ~anufacture, and test of electronics de vices (CADMAT); software development; fiber optics and opto-electronics; and flexible manufacturing:[80]

- CAD.–Government programs include demonstrations at firms, support for feasibility studies, management seminars, regional demonstration centers to permit "hands-on study, " in-depth courses to aid design engineers and production managers in implementing the technology, grants of up to 25 percent for R&D involving new applications of CAD, and grants of up to 25 percent of cost "for the design, development or launch of new or significantly improved products or processes.
- CADMAT-Government programs include management seminars, short courses for managers and engineers, demonstrations, a CADMAT information service on the state of the art of the technology and its applications, grants of up to 25 percent for the development of CADMAT tools and standards, grants of up to one-third of hardware/software costs, and support for installation and training costs of first-time users.
- *Flexible Manufacturing Systems (FMS).* —The FMS scheme was initiated in June 1982 with a budget of 60 million ($84.6 million). This scheme will provide selective financial assistance to cover some of the costs of feasibility studies, installation of a new FMS, and integrating existing plant into a flexible manufacturing system.

"Department of Industry, U.K. brochure, "Government Support for Industrial Robots. "

[78]Tim Dickson, "Caution Among the Bankers," *The Financial Times of London,* Sept. 18, 1983, p. 14.

[79]James Fleck, personal communication.

[80]Department of Trade and Industry Brochure, op. cit.

The "support for innovation" policy also is behind anticipated government funding for technical collaboration between Jaguar Cars, Ltd., British-owned Dainichi Sykes Robotics Ltd. (a joint venture between the British Sykes group and the Japanese Dainichi Kiko Company), and Dainichi Kiko. These companies recently agreed to develop new automated production systems for Jaguar automotive facilities.[81]

In addition, the National Engineering Laboratory and certain trade associations have received approximately z' 650,000 ($917,000) from DTI annually for robot-related studies. These grants have included ~' 15,000 ($21,000) to support the establishment of the British Robot Association, and ~' 240,000 ($339,000) for the establishment of Unimation (Europe) Ltd. in 1979. The National Research Development Corporation provided ~' 420,000 ($592,000) in venture capital financing for Unimation (Europe) Ltd. More aid has been proposed, but is under question due to the takeover of Unimation by Westinghouse.[az]

[81] 'Jaguar Venture May Lead to Robots, *Automotive News,* Jan. *9, 1984.*

'*James Fleck, personal communication.

Other Countries

This section examines PA in Norway, Canada, Italy, and the Netherlands. Governments in each of these countries play a less prominent role in PA than the governments discussed above, and less information is available on their programs.

Norway

Direct Government Role

The extent of use of new technologies, as well as the general health of Norway's export sector and the relative price of Norwegian products, are and have been key problems for the nation's economy .83 They have been the subject of a major study and planning efforts. Norwegian work environment programs are discussed in chapter 5.

The Lied Committee

In March 1978, the Lied Committee was appointed to study the structural problems facing the Norwegian economy and to identify areas of possible growth in Norwegian industry. While recommending a long-term strategy for Norwegian industrial development, the committee stressed that the role of the Government should be limited to providing sound macroeconomic conditions. The committee emphasized that it is not the Government role to determine which firms or which types of industries should be given priority. Instead, it suggested that the decentralized market system, wherein individual firms make decisions based on what they predict will be profitable, should continue to prevail in Norway.

"Stein Berge, Second Secretary, Embassy of Norway, personal communication, Feb. 24, 1984.

The committee suggested that the development of a long-term strategy should take into account the following conditions of Norwegian national resources:

- a considerable quantity of cheap electric power,
- full coverage of future needs for oil and natural gas,
- production of a considerable amount of oil and natural gas for export, and

- reasonable access to capital due to oil and natural gas export revenues.[84]

The committee also recommended that Norway concentrate on improving its export sector, mainly by lowering the cost of Norwegian goods relative to those of surrounding countries. This could be achieved through productivity increases, structural rationalization, minimization of wage increases, and tax adjustment.

The committee deemed the ability to apply new technological developments crucial to industrial expansion. It argued that the Government could create the proper conditions for technological diffusion through an expansion of the educational system to provide more engineers and qualified skilled workers. Finally, the committee recommended that the Government encourage the establishment of new industries based on new technologies. Though the Norwegian Government has generally accepted the recommendations of the Lied Committee, there has been no particular action based on the report.

The Norwegian Ministry of Local Government and Labor

A working group of the Norwegian Ministry of Local Government and Labor reported to the Ministry in 1980 on the potential effects of steadily increasing factory automation on employment and working conditions in the 1980's. The working group predicted that automated materials handling systems will allow the Norwegian wood-processing industry tore duce its labor force by 50 percent by 1985. It also predicted that the number of computerized numerically controlled (CNC) machine tools will increase in the machining industry, as will the application of robots for welding and spray-painting.[85]

The working group pointed out that while there is a wide range of possible applications for information technology in industry, these technologies are at different phases in their de velopment and are being disseminated at different rates to different user groups. This makes it difficult to characterize the consequences for employment. In predicting the effects that factory automation will have on the Norwegian economy as a whole, the working group argued that continuous process and electronics industries have a greater potential for productivity gains than does the metalworking industry. Although firms may imple ment the new technologies, given the small and medium size of Norwegian firms it was predicted that the benefits will be limited.

Canada

Federal Support for Technology-Enhanced Productivity Program

CAN$10 million ($8 million) over 5 years has been committed to 10 microelectronics centers through the Federal STEP (Support for Technology-Enhanced Productivity) program. The STEP program is intended to help producers of microelectronics and advanced production equipment to develop products that will be competitive in international markets. It is also intended to help users implement the technology efficiently and develop new and improved products for the Canadian economy.

STEP incentives for producers include reimbursement of:

- up to 75 percent of eligible expenditures on R&D,
- up to 50 percent of eligible costs of machinery and equipment, and
- up to 15 percent of eligible costs of buildings.

STEP incentives for users include reimbursement for:

- feasibility studies-up to 100 percent of total costs, with a maximum of CAN $10,OOO ($8,000);
- implementation of a new microelectronic product or process—up to CAN$1OO,OOO ($80,000) or 75 percent of total costs; and

[84]Norges Offentilge Utredninger, *Employment and Working Conditions in the 1980's*, NOU 1980:33.
[85]Ibid.

- design of custom microelectronic equipment—up to CAN$500,000 ($400,000) or 75 percent of total costs.[86]

Manpower Consultative Service— Education and Retraining

The Department of Employment and Immigration established the Manpower Consultative Service, a key mechanism for aiding workers displaced for economic, technological, or other reasons. The Service provides assistance to employers who work with their employees to reduce manpower levels or develop work force skills. In particular, it operates on an as-needed basis, becoming involved when mass layoffs are expected to occur, and supplementing local labor market institutions for brief (e.g., 6- to 12-month) periods.

The Manpower Consultative Service was founded in 1963 to encourage labor and management to work together on problems of worker displacement. The Service has a program whereby management and labor consult as equal partners in committees on matters of mutual concern, such as turnover, employment instability, working conditions, absenteeism, training requirements, and management studies. It provides up to 50 percent of the cost of the labor adjustment committee, and up to 50 percent of worker relocation costs if a committee transfers workers in order to keep them employed. Where new technology is the cause of displacement, the committees look at the impact on skill needs and try to develop means of counseling, retraining, and placement for those who are displaced. Both industrial training for work on new machinery or new job content and institutional training in trade schools are provided. In addition, subsidies are provided for older workers to train for new jobs. Companies do not always participate in the MCS program, as they are required to continue to pay the workers' fringe benefits during the transition period.[87]

The Ontario Board of Industrial Leadership and Development

The government of the Province of Ontario established the Board of Industrial Leadership and Development (BILD) in January 1981, comprised of cabinet ministers responsible for economic and regional development. It develops long-term investment strategies for the Ontario Government and funds programs through grants, loans, and other forms of assistance. The BILD program is budgeted at CAN$l.5 billion ($1.2 billion) over a 5-year period. Overall objectives of the BILD program are to develop an import replacement and export potential in order to improve Ontario's trade balance, technological development, training, and job creation.

The Board of Industrial Leadership and Development has recognized that new specialized skills will be required with the implementation of computer-assisted manufacturing. Under the Training in Business and Industry program, BILD subsidizes up to one-third of the cost of retraining workers, with the remainder paid by the worker and the employer. BILD also provides equipment grants to educational facilities, research grants, and career counseling services.

Under its high-technology development program, BILD has allocated CAN$1OO million ($80 million) to five industry-oriented technology centers to provide expertise to companies applying new technologies. The five centers are described below:[88]

- *The Ontaio Centre for Advanced Manufacturing.* —This center has two facilities; one for CAD and CAM in Cambridge, and one for robotics in Peterborough. Funding will be CAN$40 million ($32 million) over 5 years, beginning in 1983. These facilities will provide consultation services for the implementation of CAD and CAM and robotics, and will help individual firms tailor the technology to their needs.
- *The Ontario Centre for Microelectromics.* — This center, located in Ottawa, will receive CAN$20 million ($16 million) over 5 years. The center was opened on October 28, 1982.

[86] "The News From BILD, Ontario, " February 1983; and "Building Ontario in the 1980' s," BILD, January 1981.

[87] Harry Monk, Employment and Immigration Department of Canada, personal communication, Dec. 9, 1983; and M. Bendick, Jr., "The Role of Public Program and Private Markets in Reemploying Workers Dislocated by Economic Change, " The Urban Institute, November 1982.

[88] Brochure, "The News from BILD, Ontario, " February 1983.

- *The Ontario Centre for Automotive Parts Technology.*– This center was established in order to encourage restructuring of the auto industry. CAN$14.5 million ($11.6 million) will be provided over 5 years for development of new product designs, market research, and management information services. The center was opened on December 14, 1982.
- *The Ontario Centre for Resource Machinery.–This* center will receive CAN$20 million ($16 million) to undertake R&D for the mining and forestry-equipment industries. The center was opened on December 15, 1982.
- *The Ontario Centre for Farm Equipment and Food Processing. -This* cent~r will receive CAN$10 million ($8 million) over 5 years to undertake R&D. The center was opened on January 31, 1983.

Italy

Italy appears to have no specific policy to protect targeted industries or promote the movement of resources out of particular industries. However, the Italian Government owns a large share of certain industries (nuclear power, electrical components, telecommunications equipment, chemicals, steel, and shipbuilding) and financial institutions. The State has intervened in the economy with aid to industry in the postwar period, without an overall "industrial policy."

Most notable in Italy has been the government promotion of private investment in the underdeveloped southern regions. Investment grants, low interest loans, and tax breaks have been provided to private firms to encourage investment in the South, and Stateowned firms have been required to invest in the South. Such investment has been encouraged in order to develop this region and provide employment to avoid the migration of Southern Italians to Northern Italy.[89]

The U.S. Robotic Industries Association (RIA) estimates Italy is the fifth largest robot producer but may become the third, after Japan and the United States, by 1990.[90] Robot use in Italy is particularly heavy in automobile manufacturing. Fiat, for example, is both a major user and developer of robotic systems. Olivetti, an office equipment manufacturer, is also heavily involved with PA.

The National Machine Tool Builders' Association estimates that Italy ranks fifth in machine tool production and third in machine tool exports, as of 1982.[91] There are close research ties among machine tool producer firms, and between producers and the Government. Research projects on manufacturing are sponsored by a financial agency (IMI) which channels low interest loans and Government-funded grants to small and medium-sized firms. The Italian National Council of Research has also begun a manufacturing research program which involves several Italian universities and industries.

The Netherlands

While the Netherlands is neither a major user nor producer of PA technologies, the Dutch are increasingly concerned with "catching up" in the development and application of PA. Industrial productivity is a source of great concern to the Dutch because 64 percent of industrial output is exported. There is concern, however, that automation could lead to a loss of industrial jobs. A study by the Netherlands Center for Technology Trends concluded that the gains in productivity that could be achieved by increased automation would outweigh the labor displacement because low productivity has made it difficult for Dutch products to compete with those of low-wage developing countries.[92]

The Dutch have several programs promoting or regulating the production and use of PA:

[89] Lawrence Franko, *European Industrial Policy: Past, Present, and Future,* the Conference Board in Europe, February 1980, p. 34.

[90] RIA, Worldwide Robotics Survey and Directory, 1983.

[91] National Machine Tool Builders' Association, *1983-1984 Economic Handbook of the Machine Tool Industry.*

[92] I.H. Timmerman, *Automatisering in De Fabriek: Vertrekpunten Voor Beleid,* Delft University Press, 1983.

- The Ministry of Education and Science Policy and the Ministry of Economic Affairs launched an R&D program in October 1982 aimed at improving technological expertise and research potential at the technological universities.
- The Ministry of Economic Affairs is preparing a program for stimulating the PA industry. This program will include an awareness promotion campaign, provide subsidies and low interest loans to industry to promote investment in PA, and sponsor demonstration projects.
- The Ministry of Social Affairs will monitor employment and working environment impacts.
- The Ministry of Education and Science Policy, the Ministry of Economic Affairs, and the Netherlands Organization for Applied Scientific Research will administer education, training, and retraining programs.