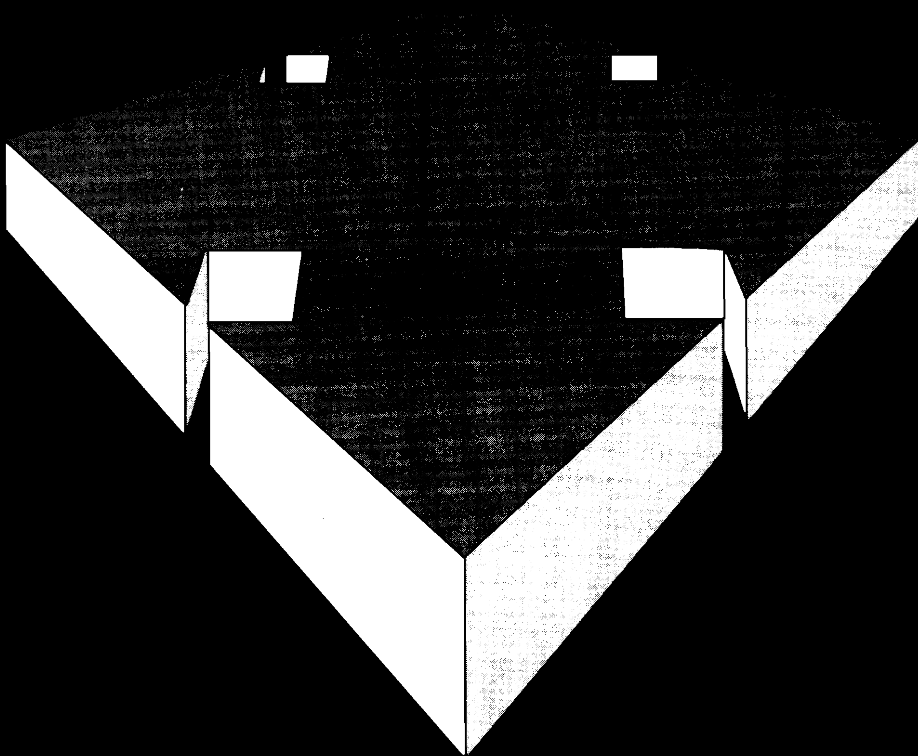
Governments and Microelectronics

Science Council of Canada

Background Study 49

The European Experience

Dirk de Vos



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Governments and Microelectronics

The European Experience

by Dirk de Vos

The Author

Dirk de Vos holds degrees in languages, law and business administration. His work experience in three continents includes legal practice and executive positions in multinational enterprises in such diverse fields as banking, the food and oil industries and in government. In view of his expertise in the field of innovation and foreign investment, he has represented Canada at various international fora, in the Commonwealth, at the OECD and at the United Nations.

Contents

Foreword

The Science Council has repeatedly stressed the demands being placed upon the people and the economy of Canada in this technologically competitive age. At no stage have these challenges been more pointed than at present, when even the most industrialized countries are struggling to survive.

Council's recent report, *Planning Now for an Information Society: Tomorrow is Too Late* underlined the extent of the challenge being presented by the microelectronics revolution. One aspect of this revolution is that many governments are finding it necessary to promote the growth of their microelectronics-based industries. Indeed, such an approach is integral to advanced economic policy making. To remain competitive internationally, Canadian business and government must become thoroughly aware of the nature of these initiatives and the directions they are taking.

Governments and Microelectronics presents brief case studies of the approach taken by five countries in Europe and Scandinavia. The author has drawn upon his experience as a program administrator in Canada to form an impression of the European situation, and has outlined the scope and character of the initiatives being taken. This study also provides a much needed, and in-depth, analysis of some of the problems and options facing policy makers.

We hope this publication will contribute towards a reassessment, by both government and industry, of appropriate policy measures for this very important aspect of Canada's future industrial structure. As with all background studies published by the Science Council, this study represents the views of the author and not necessarily those of Council.

Maurice L'Abbé
Executive Director
Science Council of Canada

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It is not possible to list the names of all the people, inside and outside the Science Council of Canada, without whose cooperation this study could not have been undertaken; the list would be too long and, in some cases, there is a need for confidentiality. I am particularly grateful to those officials in the public and private sectors who were prepared to trust and to answer the questions of a stranger in sensitive matters of public and corporate policy and practice. There is indeed a community of interest that bodes well for the future. We should continue to learn from one another.

Dirk de Vos

I. Introduction

Industrial nations are looking to new technologies, including microelectronics, to maintain their prosperity during the rest of this century. The microchip lies not only at the heart of the information age, that powerful combination of communication and computing, but is also transforming both the process of production and the service economy - not to mention the new markets that have been opened by ingenious new consumer products.

From a Canadian point of view, the opportunities and threats of the new technologies are compounded by the fact that other countries - notably the US and Japan - have had a considerable head start and are already immensely competitive. They have been able to mobilize not only the needed resources, markets, commercial and social systems but the necessary motivation for R&D, investment and risk taking across the whole spectrum of activities associated with microelectronics.

In the quest for survival that is sweeping a very competitive world, economic policy has now become technology policy. Can Canada compete?

The European Perspective

Europeans have learned that microelectronics is "the single most important sector [of the economy] for the remaining years of this century,"[1] and particular fields of application, like telecommunications, "have moved to the top of the political agenda."[2]

One leading European has noted:

> "The new information technologies are at the root of ... increases in productivity... circumstances lead us toward an economy in which the major portion of jobs and activity will be linked to information."[3]

At a 1981 Helsinki meeting, members of the Council of Europe were told:

"Future historians will view the 1980s as having been shaped by the rising influence of the new information technologies and by the ensuing worldwide struggle to realize the economic potential of these technologies."[4]

And in the words of Christopher Freeman of the Science Policy Research Unit at the University of Sussex:

"Today, electronic information technology represents [the] 'heartland' technology critical for our entire future... the critical technology for advanced industrial countries both for industry and for services... . The microelectronics revolution is not just 'one more step' in the process of technical change or one more new product."[5]

Any disagreement about the prospects relates to the speed with which the new innovations will diffuse through, and transform, economies and societies. Mr. Kenneth Baker, a British Minister for Industry, used blunt language in speeches to Parliament and to business leaders. The choice, he said, is simple: "We automate or liquidate," that is the prospect for lagging countries, industry sectors and businesses.

In Europe the opportunities are seen to be as great as the costs of being left behind. Some studies have estimated that microprocessor sales may grow at an annual rate of 30 per cent, with the world market for information technology reaching $235 billion by 1985.[6]

The Challenge

The second-tier countries of Europe and Scandinavia have not been asleep. Through the years they have built up an infrastructure of knowledge and experience in electronics and data processing, but most important, they have recognized the longer-term significance to industrialized states of a basic competence in production processes, engineering and the design and construction of machinery and scientific instruments.

As long ago as 1969, for example, the Wolfson Microelectronics Institute was established at the University of Edinburgh in Scotland. Three years later, the British government launched MISP, its first major microelectronics assistance program, favouring three nationally owned companies (Ferranti, GEC and Plessey).

The West Germans have been sinking vast public resources into electronics since the mid-1960s, followed by a major "onslaught" with their development plan for 1971-75, not to mention the succeeding comprehensive programs for 1976-79 and 1980-83.[7] According to Jean-Jacques Servan-Schreiber:

"...between 1980 and 1984 [Volkswagen and Mercedes Benz] each intended to spend ten billion deutsche marks on the electronic transformation of their factories. BMW also announced it would spend five billion marks."[8]

Even quite small economies have had a head start of at least four to five years with the kinds of studies and exhortations about promising technologies that began to surface in Canada only in 1982. For example, important official Swedish studies were launched in 1978, followed by a government directive in July of the same year. Countries with no particular claim to fame in any branch of electronics have given special attention to the demands of microelectronics; these include Switzerland (after its traumatic encounter with the Japanese digital watch industry) and Spain (which has formed a ten-man commission to draw up a national electronic plan).[9]

Still more sobering, many European governments have earmarked large amounts of money to promote the new technologies. M. Chevènement, the new French Minister of Research and Technology plans to spend no less than $555 million on electronic components alone by 1984 and the equivalent of $5.7 billion (Canadian) on telecommunications.* Comparable expenditures, for the same period, were estimated at $4 billion in West Germany and $3.1 billion in the United Kingdom.[10] The latter is not a country that can easily afford the $225 million in equity, loan guarantees and grants allocated to a single government-owned microelectronics venture,[11] or the $560 million a Labour government was prepared to earmark for microelectronics support. Yet complaints were heard that, "of major industrial economies with pretensions to a substantial electronic sector, Britain has one of the most modest programs of government support."[12]

The Study

How do governments in Europe and Scandinavia go about the difficult task of promoting investment and innovation in the new technologies? Five countries with a significant stake in electronics - the UK, France, West Germany, Sweden, and the Netherlands - were selected for study in an attempt to assess their efforts to nurture their microelectronics firms. A case study approach was adopted.†

This background study describes the situation mainly on the

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*Currencies: For comparative purposes, all country currencies were converted, unless otherwise indicated, to Canadian dollars at the ruling rates during October 1981. Because exchange rates have fluctuated considerably over the lengthy period of time covered by this study, it would not be practical to convert expenditures on any other basis. D. de Vos

†The study does not intend to tell the reader which components and applications are being or ought to be developed or exploited. Nor does it address in any detail the important instrument of government procurement which may play a significant role, especially in aerospace, telecommunications and defence. With a few exceptions, precise information on government procurement is seldom made public.

basis of interviews conducted in the fall of 1981 (in some instances more recent developments have been noted). The resulting case studies may support a more meaningful analysis of the way in which innovation policies are being implemented by governments, especially in view of the role of multinational enterprises and large firms. Interviews were almost exclusively directed to officials in government and quasi-government agencies. In other words, the primary focus was on the *supply* side of direct government support; the time available allowed only a few exploratory talks with persons in the business community.

Enough was learned, however, to underline the need for a follow-up investigation that would also take into account the points of view of the multinationals. It is of particular importance to understand the considerations that govern the attitudes and actions of multinational enterprises, if only because large firms are the main recipients of official aid despite the recent attention given to the requirements of small and medium-sized enterprises. While much has been written about policies and programs for technological innovation, we know little about the crucial role of *implementation* in this area, involving the multinationals. Therefore, this study offers no conclusions at this stage of the investigation.

For the stated reasons, the case studies are merely descriptive, with the objectives of underlining the commitment of selected European governments to the promotion of microelectronics and throwing some preliminary light on important practical aspects of government action. Support for electronics, let alone microelectronics, cannot be isolated from the broad range of official measures to promote innovation in each country. A fairly comprehensive, if nevertheless still brief, description of the broader setting for industrial support also helps in understanding some of the unique nuances of policy making in individual countries. On the other hand, it serves to show the very substantial commonalities and similarities among European approaches to the new technologies of the future.

II. The European Economic Community

Industrial Innovation

Industrial competition is serious business in Europe - a question of national survival. This is as true at the level of the European Economic Community (EEC), as for individual countries. After all, the members of the EEC are responsible for close to 40 per cent of world trade, with three-quarters of their exports consisting of manufactured goods. Their industrial competitiveness and economic survival depend on technological excellence to such an extent that Grewlich and others have earmarked technological strength as the very basis of European security.[1]

Here enters the problem of the lag between European nations and the two leaders of the industrial world, the US and Japan. It is a question that has been discussed with increasing urgency at the highest levels of European leadership for the simple reason that in fast-moving fields of advanced technological innovation, lags are notoriously hard to overcome and can, indeed, be fatal. In the words of the chairman of the European Committee for Research and Development of the EEC:

> "One must have had first-hand experience of the ups and downs of the competitive struggle for innovation to realize that it is very difficult to jump on a moving train... a place on the rungs of the international division of labour is hard won and it is very difficult to dislodge those who gain the first foothold in markets which they have won by their own pioneering efforts."[2]

The Community has given a great deal of thought to long-term needs and priorities, particularly to the demand for higher productivity. It has identified the new information technologies not only as a major field for innovation, but also as the key to achieving higher productivity. In addition, specific areas for R&D have been selected.

They include supportive activities such as telecommunications, electronics and computing, and the application of those technologies in the areas of administration (bureautique),* robotics and medicine. At the Sixth Public Parliamentary Hearings of the Council of Europe, held in March 1981, the issue was "innovation, competitiveness and political decision making." It is interesting to note that the papers presented were devoted almost exclusively to biotechnology, microelectronics, information technologies and robotics.

In 1978, the Council of Ministers of the European Communities decided to launch Project FAST (Forecasting and Assessment in the Field of Science and Technology) to help define long-term R&D objectives and priorities, on the premise that "the possible futures are not a matter of chance: they will be as our societies determine them."[3] One of three principal areas of investigation was the "information society," with one of the major subthemes being "the economic survival of European industries."[4]

Microelectronics

Project FAST's concentration on the microelectronics revolution gave rise to various activities. In 1981, the Fifth Parliamentary and Scientific Conference of the Council of Europe held a detailed discussion of "information and communication technologies and the microelectronics revolution."[5] The groundwork for these concerns had been laid with the publication in November 1979 of *European Society Faced with the Challenge of New Information Technologies: A Community Response*. This report flowed directly from a decision by the heads of state that those technologies "offered a major source of economic growth and social development," thus meriting support.[6]

The Commission of the European Communities' first proposal *Community Actions in the Field of Microelectronics* appeared in September 1980.[7] The industrial significance of new technology "for European industry as a whole" was stressed again. Not only were world markets analysed but American and Japanese strategies as well. Europe had "no choice" but to catch up by 1985. National programs would have to be coordinated; computer-aided design and testing would require special attention. However, the most urgent need cited was to develop the advanced equipment that made up the production process. Otherwise the general level of engineering capability and skills in Europe would be seriously inadequate.

Europe's lag in electronics was still being lamented a year later,[8] despite claims that European governments would be provid-

*Bureautique covers the gamut of electronic devices centred in and around the operation of offices.

ing about $1 billion in direct support during the period from the mid-1970s to the mid-1980s, and even with corporate investments from such giants as Siemens of West Germany and Philips of the Netherlands amounting to another $1 billion. On 1 July 1981, the Commission promulgated a scheme to develop the industrial equipment industry by coordinating the focus and level of state aid. In the field of telematics (i.e., where telecommunications and computing become fully integrated), the Community's official goal was to increase its share of worldwide production from 6 to 12 per cent by the mid-1980s and to reduce European dependence on imports.

The last objective illustrates a growing European conviction that, first, competitiveness in world markets must be based on a strong internal market and, second, more emphasis should be placed on the ability of public authorities to help translate grandiose schemes into tangible results and on the ability of public and private actors to collaborate. Such cooperation would be essential in any strategy designed to leapfrog over the Japanese in any specific field, for example, in the completely new world of the submicron. Realizing that talk had to be translated into action, the Community detailed Roland Huber, the former head of Project FAST, to concentrate on operational plans and their implementation.

Overview

The European commitment to the technologies of the future can hardly be exaggerated, as the Community struggles to come to grips with the details of the international challenge. Even as it requested 50 million European units of account* to support five specific key technology projects over a four-year period, the Commission still doubted the ability, or indeed willingness, of member states to pool their resources and pull together. The individual states remain very much on their own in their quest to maximize national advantage. The need to build on local strengths, combined with the hope of correcting some of the most important weaknesses, remains a primary objective.

Despite the achievements of the individual states, the Commission issued renewed warnings in a special 1982 report, *The Competitiveness of European Community Industry*. The report referred to "mediocre" performance in advanced technology and complained that the Community's lead had given way to a serious comparative disadvantage, even in relation to newly-industrialized countries.[9] As for Japan, the Commission warned that that country's investment in advanced manufacturing (as a percentage of gross domestic product) was almost twice as high as in either the EEC or the US. In

*Special currency unit used by the EEC.

May 1982, a director of Mackintosh International, a British consulting firm, called for "pan-European actions involving the establishment of a jointly sponsored microelectronics, computer peripheral technology, and production engineering R&D centre."[10]

Notwithstanding their considerable technological strengths and efforts to overcome competitive disadvantages, the Europeans are still running scared. However, to understand the nature of the challenge and the European response, we must look at individual countries in turn.

III. The United Kingdom

National Commitment

General Industrial Support

The government of the United Kingdom wields a broad range of investment and innovation policies that underlie, complement and support the promising technologies of the new industrial revolution. These measures consist of general as well as highly-specific instruments. Some support benefits are automatic, while others are completely discretionary. Sometimes the element of support for R&D may be hidden altogether, for example, in the form of military expenditures or regional development grants.

The UK was one of the first OECD countries to adopt formally industrial innovation as a specific policy. For various reasons, the British have a long and diverse experience in wielding a wide range of industrial development tools at both the macro and the microlevel. A major contributing factor was the steady deterioration, since World War II, in the international competitiveness of British industry, so much so that "industrial adjustment" has been the cornerstone of industrial strategy. At one point in the early 1960s, no fewer than 40 sector working parties, with representation from government, management and labour unions, assembled to address these problems. A great variety of schemes straddling both general and highly selective policy instruments ensued. They involved the rescue and propping up of old enterprises such as Chrysler, British Leyland, Alfred Herbert, Norton Villiers Triumph, Meriden Cooperative, as well as the encouragement of advanced development, such as in the aerospace sector.

The government has contributed a great deal to the supply side of the economy, particularly on a sectoral basis. The powerful Industry Act of 1972 created a highly differentiated regional incentive program as well as a selective investment scheme. Section 8 of this Act enabled more than $560 million worth of direct assistance to be given to projects valued at $2800 million by June 1979. A system of capital allowances bolstered this measure, which, in 1978-79, cost the government $6000 million. These figures do not include the very substantial capital investments made directly by state-owned enterprises (British Steel alone accounted for $4500 million between 1974 and 1978), nor equity financing given to companies like Chrysler and Leyland. In 1979, regional development grants totalled $830 million, and funding by the National Enterprise Board (NEB) ran at gross levels of $765 million and $625 million, in 1979 and 1980 respectively. Operating under new self-imposed guidelines, the British Technology Group* announced, in 1981, its intention to concentrate on commercial activities in high technology.

At one stage, a National Economic Development Council (NEDC) paper on adjustment expressed a growing disillusionment among various European countries with policies that have tended to inhibit structural adjustment. The Council advocated a renewed emphasis on "across the board policies" in conjunction with some sectoral schemes. The tax system is an example of one such policy; the British government claims that its overall tax burden on companies is "amongst the lowest in Europe."[1] For the construction of large industrial buildings, companies can write off 79 per cent of the cost in the first year. A stock relief system allows companies to make deductions from their profits to take into account increases in stock values due to inflation. New companies can fully write off expenditures on plant, machinery and scientific research in the first year of operation.

The figures quoted above indicate the amounts of public money consistently poured into the support of industry, under one program heading or another. Among those programs, the regional development grants have accounted for a large share. Significant features of regional development assistance relate, for example, to capital expenditure write-offs of 100 per cent and 79 per cent in the first year. Despite these generous write-offs, the regional development grants are *not* deducted from the cost of capital assets for the purpose of calculating depreciation. Such grants are not treated for tax purposes as income receipts, and do not give rise to any company tax. For tax purposes it is assumed that the firm has itself contributed such moneys. This system allows the firm to claim depreciation on government money. The rates of grant vary from 15 to 22 per

*In 1981, there was a merger of the NEB (a state holding company which helped firms to expand into profitable areas of manufacturing) with the NRDC (a state holding company which promoted the exploitation of inventions) to form the British Technology Group.

cent, but they are entirely automatic. Even firms whose presence in the UK might be rather unwelcome are entitled to the grants, once they can show they are in the country, undertaking manufacturing (including related scientific research), and spending capital on buildings, plant and equipment. No other conditions are imposed, not even an obligation to create jobs.

Next, under section 7 of the Industry Act,* is selective regional assistance which is only available in so-called "areas of expansion," but which may accrue to mining, manufacturing and construction. No statutory limit is imposed on the amount or percentage of grants. They can be paid on a project basis, related to fixed and working capital costs and the number of jobs involved; can contribute 40 per cent of training costs, which can be added to another 40 per cent provided by the European Social Fund (ESF); provide guarantees against exchange losses on loans from the European Investment Bank (EIB); allow rent-free use of modern workshops (a feature relating to the availability of government factories, which can also be bought on generous terms); or any combination of the foregoing. Unlike the general regional development grants, these grants can be front-end loaded (payable as expenditures take place) and loaded on top of basic grants. They are after-tax grants.

Major projects in the national interest are assisted by section 8 of the Industry Act.[2] Not confining eligible project costs to new fixed capital investment in buildings, plants or machinery, section 8 allows grants to include working capital, preproduction or development costs, market development expenditure, licensing arrangements and relevant training costs. Once again there is no statutory limit, except for EEC regulations, and these come into play only at fairly high levels of support. These grants may also be added to the basic regional development component.

Other general sources of investment aid include equity and loan finance provided by the British Technology Group and by the Development Agencies for Scotland, Wales and Northern Ireland. Also, local authorities including the county councils, which are anxious to diversify industry without the interference and discretion of the central government in London, are intervening in an increasingly active and competitive way. For manufacturers, the investment climate is improved by various *nonspecific* forms of assistance, such as the British Manufacturing Advisory Service, which subsidizes consulting agencies; companies can receive free engineering and manufacturing advice for a period of 15 days. Firms with as many as 1000 employees

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*Section 7 of the Industry Act applies only in assisted areas, with cost-per-job limits, and presents lower qualification hurdles than section 8; section 8 relates to manufacturing firms anywhere in the country and has no statutory limit. For further information and a comparison with the 1965 Science and Technology Act, see p. 31.

may qualify. Extensive seminars given by British scientific counsellors at the firm level are so effective that industry has been prepared to pay a fee for the service.

Firms located in so-called special development or development areas may also enjoy preferences where governments, nationalized industries and other public bodies let contracts for the supply of goods and services. Government departments and the post office are entitled to help firms in special areas to "cut into" a contract to the extent of 25 per cent of an order, where the lowest successful tenderer is outside a special area.

Finally, "enterprise zones" qualify for special grants, mainly for the benefit of small and medium-sized firms. The objective is to "cut red tape" related to the use of industrial sites of no more than 200 ha in size, and offer exemptions from rates and development charges (the usual 100 per cent capital allowances), exemptions from so-called industrial trading requirements and even assistance in speeding up customs-clearing procedures.

Research and Development

As long ago as 1948, the government founded the National Research and Development Corporation (NRDC)* to develop and exploit inventions on a commercial basis, starting the venture with a capital fund supplemented with relief from interest payments on loans. In 1973, the government established six (later increased to ten) Requirements Boards to control part of the R&D expenditures of the Department of Industry. In May 1981, the Boards were consolidated into five. At present they disburse some $135 million each year, of which 60 per cent goes to external research in industry and the rest to research by the department's own establishments. Coupled with government research establishments' efforts to determine R&D needs over a time period of 20 years, the boards have tried to plan the nation's R&D needs five to ten years ahead. Their focus is on applied research and the need to encourage the exploitation of the results of R&D; they are chaired by senior industrialists, and have a strong industrial membership.

At the institutional level, a vast network of research associations complement these boards. Their purpose is to create research cooperation among industries on a scale which, by 1979, covered 93 per cent of the industrial base. By 1967, there were already more than 21 000 member companies. In 1979, direct government funding of the associations amounted to $24 million.

Among specific programs to promote R&D, the government launched the noteworthy Product and Process Development Scheme

*See footnote on page 20.

(PPDS) in 1977, under the provisions of the 1965 Science and Technology Act. Grants of up to 25 per cent (exceptionally on a 50-50 shared cost basis) are available for the design, development and launching of a new product or process, or for a significant modification of an existing product or process. The government may also assist companies by placing preproduction orders. This rather ingenious scheme permits manufacturers to lend their new products on trial to users, before they decide whether to purchase. The government could also use its good offices to persuade a nationalized industry to develop and display new equipment even in cases where the industry did not need or could not afford the equipment. The government would meet the operating costs for a year or two and if, in the end, the nationalized industry wished to use the new equipment, it could acquire it at a significantly depreciated price.

The sheer volume of public resources being poured into R&D may be judged by the fact that the Department of Industry's statistics anticipated on 15 December 1980 that expenditures on R&D schemes and programs for the year 1980-81 would include:[3]

	$ 000
Product and Process Development	51 215
MAP (R&D component)	18 000
MISP (R&D component)	5 060
R&D Requirements Boards	139 275
Manufacturing Advisory Service	6 975
Industry Act (Section 8) (R&D component)	15 750
Space Technology	96 890
Civil Aeronautics Technology	54 840
Total	$ 388 005

In 1982, the department's budget for scientific and technological assistance was raised to $585 million, representing a growth of 50 per cent in real terms over four years.

Electronics

This brief overview of the more general industrial and R&D support systems illustrates the environment within which the British government has tried to promote advanced technologies. As Sir Alec Cairncross' address to the British Association in 1971 indicates the government had even then made technological innovation a major source of economic growth, "an object of conscious policy."[4]

A strong technological capability in electronics has existed in the UK for many years, based mainly on substantial advances during World War II. In an effort to build on, and safeguard, British achievements in computer technology, the government contributed 35 per cent of the holdings of International Computers Ltd. (ICL) in 1968. Subsequently, the government, through the NEB, took positions in companies such as Ferranti (50 per cent) and Plessey (25 per cent). Software advances were assisted by establishing the National Computing Centre (NCC) in 1965 and bolstered once again in 1977 when the government, through a wholly owned corporation, INSAC, took positions in numerous related companies.

An international British presence in telecommunications flowed partly from the development of one of the first packet switched networks, and the subsequent involvement of the post office in new product development. The NEB supported NEXOS, a company specializing in office automation, and a computer-aided design centre was established in Cambridge. The government also launched extensive retraining schemes, allotting half of the available places at the Civil Service College to data processing specialists. By 1976, through public procurement, British sources supplied 60 per cent of the computers used by the central government, 57 per cent by the local government and 49 per cent by public corporations. Because the use of electronics in aerospace and defence is so extensive, it can be assumed that a substantial part of the heavy public support in those sectors must have directly benefited the electronics industry.

Microelectronics

British awareness and action in the field of microelectronics are outstanding examples of a selective and pointed approach to industrial development. Political leadership is evident from such Conservative party publications as *Proposals for a Conservative Information Technology Policy* and *Cashing in on the Chips*,[5] as well as from a comprehensive analysis of microelectronics policies by the Labour Party in 1980. The special importance attached to the new industrial revolution took a real impetus from "Now the Chips are Down," a much-discussed BBC television program screened in 1978. The Prime Minister's Advisory Committee (ACARD) released *The Applications of Semiconductor Technology* in the same year. This report was closely followed by *Joining and Assembly: The Impact of Robots and Automation* in 1979, and *Technological Change: Threats and Opportunities for the United Kingdom*, *Computer-Aided Design and Manufacture*, and *Information Technology* in 1980.[6]

Throughout the reports, ACARD identified information technology, i.e., combining the technologies of computing and communications, as perhaps the most important application of microelectronics, without denying its equally substantial impacts in the general field of product manufacture. ACARD viewed the incorporation of information technology in equipment sold to "final" customers as a major objective of each competing industrialized country, and was aware of similar activities in Japan, the US, West Germany, France and elsewhere. It identified a series of constraints upon progress in the UK. Remarkably, however, it recommended no increase in government-funded R&D, in the belief that successful application of R&D in the form of marketable products does not, in general, come about unless the R&D is carried out close to manufacture, marketing and applications. Still, as far as government support was concerned, ACARD recognized that because the UK could not compete in all areas of microelectronics development, a selective approach would be required. And as in Sweden, ACARD claimed that the responsibility for public decision making was too fragmentary for such a nationally important subject and recommended that responsibility for taking a view of the whole field of information technology should rest with one part of government. In this respect, ACARD referred approvingly to the "coherence" of the French efforts.

Following ACARD's recommendations, benefits given out by the more general supporting agencies and programs, such as the NRDC, the PPDS, the training schemes and the Requirements Boards, not to mention the counselling provided by agencies such as the Manufacturing Advisory Service, soon shifted towards microelectronics. The PPDS, for example, promoted work on new types of industrial robots and a computerized ordering system for the book trade. For the government, promoting public awareness became a high priority once it had decided that the pervasiveness of the new revolution would involve, and demand, systemic social and industrial changes.

Specific Programs

In July 1978, the Department of Industry introduced the Microprocessor Applications Project (MAP), with an initial budget of $160 million, to encourage the diffusion of microprocessing throughout industry. MAP covers awareness, training, consultancy and project support. Twenty-five per cent grants (raised to 33 per cent in 1982) for eligible projects and support for training courses, constitute the bulk of the program; up to $4500 of the cost of initial consultancy for businesses can be refunded. By 1980, some 2000 directors of large companies had attended 150 one-day workshops, and some 120 000 people had been attracted to more than 1000 other events and presentations. The department expected educational organizations to have 36 000 places available for short courses in microelectronics by 1981. MAP also instituted a "teaching company program" to be undertaken jointly between manufacturing companies and a university or polytechnic. The people selected for training were normally employed for two years to bridge the gap between the teaching institution and workplace and to accelerate learning and practice; salaries and university support costs were met by the Department of Industry and the Science Research Council (SRC). MAP offered funds to the Trade Union Council (TUC) to allow 65 000 shop floor workers to undergo training ; prizes of 100 microcomputers were awarded to secondary schools for the best essays on the use of computers in schools ; and 20 Information Technology Centres were set up for school-leavers, proposing in January 1982 according to *The Times* to create 100 such centres at a cost of $7 million each.* By October 1980, the Project had held exhibitions demonstrating microelectronics applications at 11 national trade union conferences, at the Microelectronics Centre in London, and for Members of Parliament at the House of Commons; attendance at one such exhibit in the science museum was expected to reach over two million.

By April 1981, MAP had processed more than 400 projects. It also created a Microtrain, which initially would visit 21 major centres throughout the country over a 21-week period, to provide training, conferences, seminars, consultancy sessions and even hands-on experience with equipment. In 1981, 40 000 people visited the Microtrain. At the same time, MAP's awareness program concentrated on specific industrial sectors, the first being the plastics industry. Also that year, the Department of Industry announced accelerated procedures for grant applications and abolished lower limits on the size of firms qualifying for grants.

MAP has the widest possible coverage, and its work was complemented by a second program, Microelectronics Industry Support Scheme (MISP), also announced in July 1978. Designed for a more concentrated impact, MISP is slated to provide $160 million by way of grants of up to 25 per cent (raised to 33 per cent in 1982) of qualifying project costs, cost shared contracts of up to 50 per cent, and support by way of preproduction orders for development of processing equipment to assist the electronic components industry. Its specific objectives are to expand the production of standard types of integrated circuits, develop a capability for the design and manufacture of integrated circuits for specific uses, and help companies that supply equipment or services to the microelectronics industry. Grants are highly selective. Major recipients have been the semiconductor operating divisions of the major British-owned electronic manufacturers, Plessey, General Electric Company and Ferranti, as well as a number of multinational enterprises, including Mullard (owned by Philips N.V. of the Netherlands), National Semiconductor, Motorola and General Instruments. The exact amount of support extended under the scheme is unknown.

In 1981, the Department of Industry inaugurated a Joint Appraisal Scheme, offering a cooperative venture between itself, a

*As a complementary activity, the BBC initiated an ambitious computer "teach-in" television series, using the Acorn microcomputer.

number of banks and the NRDC, and providing each participating financial institution with details of projects funded under MAP but requiring more money to proceed. By January 1982, twenty such projects had won private-sector backing. The Joint Appraisal Scheme is an example of an increasing willingness on the part of governments, not only in the UK, but also in other countries, to entrust more responsibility to various types of *intermediate agencies* in the promotion of innovation.

Reorganization and New Ventures

In November 1980, the Department of Industry reorganized its handling of the electronic industry and created the new Information Technology Division reporting to a separate junior minister. The Division was to improve policy coordination affecting telecommunications and computing. Subsequently, the NEB commissioned the PA International Group, a consulting agency, to prepare a special report outlining a strategy for information technology.[7] After a Cabinet shuffle in January 1981, a new Minister of State for Industry, Mr. Kenneth Baker, was appointed, with responsibility for all activities affecting the electronic industry. Baker launched a vigorous promotion campaign to encourage wider use of existing information processing equipment in commerce and administration, earmarked some $180 million for the purpose, and designated 1982 as "the year of information technology." In the same year preliminary plans were in the works for 8 demonstrations of advanced office technology in the public sector (eventually there would be 11 office automation projects, each costing $1 250 000) and a mobile exhibition, similar to the MAP microtrain, to tour the country by road. The 1982 campaign was entrusted to a committee drawn from industry, trade unions and government.

In the late 1970s, the NEB became involved in various electronic enterprises. In July 1978, Cabinet approved an investment in INMOS, a new firm, of $120 million in two instalments. INMOS spent the first installment on recruiting design and engineering teams and on building and equipping a microelectronics research facility at Colorado Springs in the US to develop expertise for eventual transfer to the UK. INMOS aimed to meet Japanese and American competition in the manufacturing of a random access memory (RAM) chip, capable of storing 64 000 bytes of information. It was estimated that by 1985, annual sales worldwide of 64K RAMs could reach $2 billion. In view of predictions that Japanese companies would eventually hold 40 to 60 per cent of the American market by the end of 1980, the INMOS decision was widely hailed as most courageous. In backing INMOS, the British government had taken a far bolder and riskier approach than its European counterparts, especially for example, France, which was then relying on joint ventures with foreign firms.

The NEB also formed NEXOS, a product development and marketing company, to assemble the products of British office equipment manufacturers into a unified and compatible range and develop new ones for the office of the future. In addition, the NEB funded small microelectronics firms, for example, Hytec Microsystems which adapts small business systems to large computer networks. By September 1981, the NEB had received applications from more than 300 business firms.

In 1981, the British Technology Group reported two equity investments, a move indicative of their involvement with American firms. Other small equity holdings by the British Technology Group include Insac (software marketing), Q1 Europe Limited (microcomputer systems), Quest Automation (computer-aided design) and Aregon (viewdata software products). By March 1982, the Group had also made 40 investments in the field of biotechnology, with the board of directors earmarking another $35 million for further explorations in this area. Indeed, the British Technology Group is probably the most active example of the determination of the British government to help industry master the new technologies.

Other Applications

Government support for *robotics* was well under way in 1981, being extended partly under the broad provisions of the PPDS and partly through the Production Engineering Research Association (PERA). Where the installation of a robot is warranted, the Association provides, free of charge, terms of reference for an advisory project. If accepted, the Association supplies technical advice, economic appraisals and feasibility studies at 50 per cent of cost. Section 8 of the Industry Act assisted an American company, Unimation, a world leader in robotics, in setting up a plant at Telford to manufacture robots for lightweight industrial use. In February 1982, the government announced a plan to expand the support scheme for the manufacture and use of robots, especially new flexible manufacturing systems. The Science and Engineering Research Council (SERC) was involved in 22 major development projects in robotics that linked industry with academic resources. General Electric, having decided to be a world leader in robotics and factory automation systems by 1986, set up a new division to advance robotics with the help of the Department of Industry.

In July 1981, the government launched an Optoelectronics Support Scheme, with initial funding of $55 million, to provide 25 per cent grants (raised to 33 per cent in 1982) towards the cost of R&D, plant and buildings and technical applications. The Scheme encourages international joint ventures to help the local fibre optics industry. In 1981 as well, British Telecom, the West German PTT and the West German Bundespost signed an accord to promote common procurement of fibre-optics cable. Because neither country had a sufficiently large current demand, they agreed to buy from a single factory to be erected in North Wales, in conjunction with an American firm.

This example of the marshalling of public sector *procurement* in telecommunications is merely a reminder of the extent to which the British are harnessing procurement to promote national competitiveness in microelectronics. British Telecom was the first national network to be firmly committed to fibre optics, sending orders to Plessey, GEC and STC (a subsidiary of ITT) for more than 6400 km of optical fibre in addition to 3200 km already being installed.

At one extreme of procurement is a sophisticated consultative and contracting approach by the National Defence Industries Council (NDIC), chaired by the Secretary of State for Defence. The Council, composed of electronic companies and major trade associations, tries to look far ahead at technological innovation needs in the industry. It meets twice a year. A "procurement executive management board" meets about six times a year with the main boards of firms like Marconi, Ferranti and Racal. At the other end of the procurement spectrum is the linking of a new program, the Microelectronics Education Programme (MEP), with the purchase of at least one microcomputer for each secondary school in the UK. The program's aim, by the end of 1982, is that every 16 year old leaving school will have had "hands-on" experience with a microcomputer. MEP provides full details of available microcomputer packages to schools and educational authorities and the Department of Industry contributes to half the cost of the acquisition of a microcomputer.

No mention has yet been made of the special efforts of government agencies like Invest in Britain Bureau, the numerous analyses and reports produced by NEDC (including the Economic Development Committee for the Electronic Industry) with its tripartite structure of consultation among industry, labour and government (chaired by the Prime Minister), and the public awareness role of ACARD. These reports on various aspects of innovation, computer applications, biotechnology, automation and information technology have made a considerable impact on public opinion and policy makers. Nor has mention been made of the deliberate outward-looking policies represented by, for example, a memorandum of understanding that the government signed with the Japanese Ministry of International Trade and Industry (MITI) in September 1981, agreeing to cooperate in the fields of computers, telecommunications, robotics and computer-aided manufacturing. Also, within the confines of this study, it has not been possible to do justice to smaller initiatives such as the Software Products Scheme, which, since 1973, has financed 50 per cent of the cost of developing and marketing new or extended software products.

Practice and Implementation

The Investment Climate

British approaches to fostering investment and innovation are an object lesson in pragmatism. More than any other West European country, British authorities have had to learn to live with contradictions. More than most, if not all, of their European partners, they have had to struggle with a chronic lack of national consensus on the nature and extent of government intervention in industry. However, policies have also been surprisingly continuous under both the Conservative and Labour governments, although a distinct feeling of an undue variability and inconsistency of economic and industrial policy measures over the years has surfaced. Possibly variations were not fundamental to industrial change but were affected by, or responses to, fluctuating levels of demand in the economy.

British officials consistently maintain that the main objective of industrial policy is to establish a favourable investment climate, and that horizontal or macroeconomic climate measures come first. Some ministers even insist that forecasting is impossible and so is an ability of governments to pick winning markets, technologies and firms. For related reasons, ministers could live comfortably with the need to bail out ailing firms like British Leyland, but were unenthusiastic about supporting any so-called "promising new activities."[8] Even an indicative planning body such as the NEDC experienced difficulties in taking a coordinated, "strategic" approach to future needs. Being a genuine tripartite organization comprising government, industry and labour, the NEDC must still establish a consensus before any action can take place. This can be compared with the French Planning Commission, which, although tripartite as well, has an extremely powerful and independent commissioner. Yet credit must be given to the NEDC and the NEB for their efforts to involve customers, academics and consultants in intensive consultations, and for their early recognition of the convergence of computer technology, communications and microelectronics.[9]

The government's continuing commitment to foster a favourable climate consists of an avowed fight against inflation, supply-side and other policies to improve the efficiency of markets. However, the government gives only a limited degree of direct support for industry, even though in the same breath acknowledging selective assistance as both wise and necessary, especially in the field of technological innovation, because "intervention is a fact of life."[10] The real question, though, is not *whether* assistance is required, but *how* to deliver it most effectively. The following thoughtful assessment expressed official attitudes to industrial intervention in 1981:

"The significant factor is that there is now a Cabinet, some of whose key members believe in Government intervention in

> industry, in planning, in selectivity in promoting industrial sectors and projects - almost indeed in backing winners - and even in dirigisme [planning], French or Japanese style. Their approach to the economy is that of the technocrat rather than the monetarist ... why not capitalise on the reality and seek to ensure that the economy that emerges at the end of the recession is ... competitive and capable of surviving reasonably well for the rest of the century?"[11]

Terms and Conditions

Some direct assistance programs are more or less automatic; there is little discretion in granting, withholding or imposing conditions. Our present interest is in the discretionary grants, which are mainly based on the Industry Act of 1972 and the 1965 Science and Technology Act. Comparing the benefits of the Industry Act with those of the Science and Technology Act, the major difference appears to lie in the percentages of assistance that accrue; in both cases considerable room exists for negotiating applicable conditions. Under the Industry Act, average grants have amounted to no more than 10 to 15 per cent of project costs, although their value is enhanced by the fact that they are "front-end loaded" and can include working capital. By contrast, the percentage grants of the Science and Technology Act for technological innovation generally offer a choice between a 25 (33 per cent in 1982) and a 50 per cent grant. The latter alternative only relates to outright research; it was never an option on large production projects, even if they included product development. In practice, there does not seem to be much difference between the bargaining conditions for a grant under section 8 of the Industry Act and a 25 (or 33) per cent grant under the Science and Technology Act. Substantial differences, however, exist between lower level grants under either Act and the so-called 50-50 agreements of the Science and Technology Act.

With respect to the lower-level grants, a government offer pursues various, more-or-less standard objectives. Project results have to be exploited inside the UK for the first five years after project completion, the recipient firm cannot transfer any related manufacturing to any other country. Nor can it license its technology to any other person, including its parent corporation, without the express consent of the British government. A firm target date for the completion of a project is negotiated. If the firm does not reasonably exploit the new technology within three years, if it is being used for a purpose other than that stipulated in the contract, or if the company changes ownership, the government can intervene. (On occasion, this ownership condition could be a useful industrial restructuring tool in the hands of the government.) Government can also compel the company to license the technology to some other entity, or require complete repayment. Under such conditions, a firm must be prepared to treat the grant as a loan until it is certain it has met contract conditions. "Additionality" (an assurance that the project would not have been undertaken in the absence of government support) is also a standard requirement.

Flexibility

With respect to terms and conditions, the government is flexible. At least one independent practitioner is convinced that officials are sufficiently sensible to realize that, in the case of some multinational enterprises, a five-year ban on foreign manufacturing or licensing could be counterproductive. And with the additionality requirement, a company does not always have to prove that it would not have proceeded with a project without a grant. Instead, the company can show that funding would pull a project forward by several years. In practice, the most effective argument is for the company to demonstrate that it is engaged in an industrial sector subject to a high degree of mobility.

Governments have had to learn to live with multinational enterprises in a footloose industry.* The British government set up an electronic assistance program specifically for British-owned firms, but eventually relaxed that requirement. Collaboration with foreign firms is now actively encouraged. Recently, for example, two well-known British electronic firms took licences from an up-and-coming Canadian company; the parties agreed that the two British partners could develop the Canadian technology further and could act as each other's second sources. Despite this evidence of flexibility, the government attempts to impose conditions to ensure benefit to the UK. For example, in this case, government consent was required to license the improved technology back to its original Canadian contributor.

When it comes to any other corporate performance criteria, the information is understandably vague. Some contracts might, on occasion, refer to local content and export targets. On the whole, however, government is not concerned with the export performance of British-based firms. Certainly, under section 8 of the Industry Act, a firm has to show that an investment would be advantageous to the economy and might also have to prove an absence of *disbenefits* as, for example, a dysfunctional displacement effect on existing industry. Apart from seeking assurances about British content and

*Demand on government flexibility is further increased by the fact that in most cases a 25 (or even 33) per cent grant is hardly enough to swing a worthwhile project, especially in microelectronics, where front-end capital costs are becoming so heavy that the grant could be almost incidental.

occasions when a minister might meet with the chairman of a large company to discuss aspects of good corporate citizenship, public service spokesmen strongly disavowed the capability of governments to control R&D results, let alone the performance of a company as a whole.

Apart from the fact that the British welcomed their presence, many subsidiaries of large American firms established themselves in the UK for sound business reasons and were doing genuine R&D, including useful technology transfers. Various foreign-owned subsidiaries were "fully complete in their respective mandates" and "behaved like British companies."[12] In at least one case, fruitful cooperation between the government and the company was the result of much hard work on both sides, including special efforts of government officials to comprehend the global strategies of the multinational group and the motivations of the responsible individuals. Government realized that each company had a unique history and certain unique attributes. Personalities could play a decisive role when the government set out to identify sectors that would benefit most from microelectronics programs. A general approach to the business community failed to work initially because "the promotional efforts of the government were not hitting the right people in the companies."[13]

Among the more businesslike developments on the British scene was an emerging willingness of firms and government officials to meet to discuss a series of business plans. A company might bring forward a statement of its future intentions, an elaboration of its own assessment of future performance or a statement of the technologies it wished to develop. For its part, the government would then earmark money for that company in terms of an "understanding." A particular example is MISP, whose funding is heavily concentrated on a few large firms. Initially, MISP set aside some $165 million (later reduced to $120 million); eligible companies could come forward for payments for particular projects previously identified in an "understanding." However, government and some corporate personnel doubt that this type of relationship would work, particularly with foreign-owned companies, if government used the occasion to go on a "fishing expedition" for corporate information.*

A firm's desire to maintain an arm's length relationship from government accounts for a general preference for 25 (or 33) per cent grants rather than the more onerous 50-50 agreements. The latter not only involves complicated accounting, but also the opening of the company's financial books and a continuous return to the government by way of a levy on subsequent sales.

*One company withdrew a large project when it was unable to comply with the government's expectation of a considerable degree of disclosure, for example, about forecasts, technology and even licensing to other firms.

In the instance of the NRDC, however, 50-50 ventures did not seem to pose much of a problem. Despite higher administrative cost, firms were willing to enter into such agreements with the NRDC because the NRDC was, unlike government departments, in a position to take an equity stake. Nevertheless, companies appeared to accept the 50-50 venture even in a straight cost-sharing agreement. Perhaps the real reason firms were prepared to participate in such ventures was that the NRDC never took the government in as a third partner, only allowing government to contribute up to 25 (or 33) per cent, with the 50-50 arrangement loaded on top of that. Another factor was a claimed tendency on the part of government departments to *initiate* agreements. The NRDC, on the other hand, would merely respond to proposals from the private sector, making *no* attempt to gain access to information about aspects of the firm's business unrelated to the project in question. Each contract was custom made and although the firm had to show "benefit to Britain," the NDRC imposed no legal requirement to exploit project results in the UK or to locate facilities in depressed economic regions; rather the emphasis was on financing projects, products and technology. This was distinct from the NEB which was primarily interested in promoting healthy *firms*.

Overview and Prospect

Along with many European countries, the United Kingdom has had the benefit of a vast infrastructure of industrial knowledge and skills. This is illustrated by an impressive list of British technological achievements compiled by the Department of Industry.[14]

On the other hand, any onlooker from a country barely started in the technological race must find it sobering to learn that, even as late as 1982, the British Policy Studies Institute complained that the UK was falling behind in microelectronics.[15] "Our strategic planning is diabolical," said the director of the National Computing Centre. "We skimp our homework ... UK industry needs to get its act together."[16] Mr. Kenneth Baker has had to repeat his "automate or else" warnings, reminding the Institute of Directors, a professional organization composed of company directors, that "the combined turnover of the six biggest British-owned information technology companies was about equal to that of Siemens of West Germany, which was itself sixth in the world league table."[17] At an automated manufacturing conference in London in February 1982, there was "an air of desperation and some resignation"[18] coupled with "serious doubts whether Britain [would] will make it into the new manufacturing era."[19]

For these reasons, the government could not let up on its push for more investment and innovation in the critical areas of industrial activity. With Britain on the verge of 1982, a year specifically devoted to information technologies, it was inevitable that many of the new initiatives were concentrated in microelectronics. Research consortia covering electron-beam technology, design technology, logic arrays and new materials were established; the consortia combined public and private resources and were partly funded by government. Further systematic efforts would identify industry sectors for special microelectronics development using criteria such as industry performance, geographical distribution, the measure of diffusion within the industry, its investment record and, of course, factors such as savings in energy consumption.

The new thinking of the Economic Development Committee for Electronics would also have an impact. The Committee pointed out that microelectronics had begun to combine sectors that had been separate and that common core technologies had become a vital factor for industrial development. Still greater efforts are required to come to grips with national strengths and weaknesses, and to improve the capability to deal with multinational enterprises. The NEDC is increasingly conscious of the growing sophistication with which other governments are approaching the problems experienced by firms in breaking into world markets.

The government is flexible in its delivery of direct public support, offering companies a broad choice between fairly onerous cost-sharing agreements, and smaller grants with more flexible and less demanding conditions. The options enable the government to bargain fairly freely with individual firms, in recognition of the merits of each particular case and the proclivities of the recipient business. The main weakness of the public support system is in the automatic but still generous regional economic incentives. Foreign investors can qualify for generous subsidies even when their motives for settling in Britain might be dubious, in that there might be little technology transfer and the local displacement effects might not be advantageous.

In microelectronics, design capability is becoming far more important than fabricating; components are becoming both more specific and more programmable, with customized work expected to become the dominant theme of the second half of the decade. The government realizes how self-defeating it would be to syphon off public funds to firms not planning to contribute in this direction.

A greater degree of *selectivity* in public support is inevitable and already a growing theme in discussions of future policy. Not only is selectivity required from a technical and product marketing aspect, but also in the determination of the kinds of firms that ought to be favoured in the competition for scarce public resources. Firms have to be nudged in the right direction without, however, resurrecting the traumatic visions of Anthony Wedgwood Benn,* whose previous initiatives in government produced a long-lived backlash against joint planning ventures between governments and large firms. This heritage still impedes even modest new proposals for joint planning.

*Mr. Benn had proposed vast planning agreements between government and large firms, which also involved the participation of employees. Detailed commitments to employment, exports and other types of corporate behaviour would be exchanged for government favours.

IV. France

National Commitment

General Industrial Support

France is the leading example among those OECD countries in which government policies to stimulate investment and industrial innovation are distinguished by "specific measures," namely, direct financial aid to specific firms in a highly interventionist or dirigiste mode. Typically, the French government has not made any secret of its commitment to wield direct and even discriminatory industrial development instruments; it insists openly and repeatedly that international, multilateral constraints upon the freedom of French authorities to wield such instruments would be an unacceptable intrusion upon French sovereignty and the prerogatives of the state. This position is most evident with regard to official dealings with business enterprises in which the French government has a direct financial stake.

Thus the legitimacy of official distortions of markets (in the face of sustained efforts by others, through various international agreements, to prevent or to minimize the spreading of overt protectionism) does not have to depend on elaborate invocations of the usually "acceptable" categories of state intervention, such as the dictates of regional economic disparities, structural adjustment, or the exemptions warranted by the requirements of national security objectives. Over the past decade, fully 75 per cent of French governmental expenditure on policies to stimulate innovation has consisted of direct financial aid measures. French authorities have described "specific instruments policy" as the mainstay of industrial planning. Its main feature and its objective are to target official aid through a highly planned orchestration of support measures.

Nevertheless, like other industrialized countries, France also has a panoply of general subsidies and supports, which provide an "infrastructure" to industrial innovation and investment. As usual, *fiscal measures* are the most general. There is, for example, a deduction for new firms amounting to one-third of taxable profits for the first four years. For increased investment, 10 per cent of such annual increases is deductible from profits. Loss of revenues to the state on this account amounts to an estimated $1.1 billion (1981) per year. Individual investors on the stock exchange enjoy tax relief, in order to assist firms in raising equity finance.

As elsewhere, regional economic development support is extensive. The Regional Development Premium (PDR), established in 1972, channels grants to designated areas varying from $3250 (1977) per job created (up to a maximum of 12 per cent of the value of an investment) to $5400 per job (to a maximum of 25 per cent). In 1977, grants totalled more than $44 million (1977). To these premiums may be added, from $10 800 to $21 600 (1977) for new projects that create between six and ten jobs. A Special Fund for Industrial Adaptation (FSAI) has, since 1978, aided ailing, mature industries, under a budget totalling $550 million (1981).

An Interministerial Committee for the Development of Investment and Protection of Employment (CIDISE) assists, through loans for equity investment, small to medium-sized firms with high performance potential; assistance is almost automatic if a firm is profitable and exporting and if shareholders match the government's contribution. The loans are long term and without guarantee.

One of the most powerful general instruments is a system of interest rate rebates, granted by the Crédit national, whose total loan portfolio amounts to $5.5 billion spread over 4000 firms. These rebates are not large, but if they are geared to other assistance schemes, their total leverage can be quite powerful. In February 1982, M. Chevènement, the new Minister of Research and Technology, reiterated the government's commitment to interest subsidization for new projects, which would be freed entirely from credit controls governing the French bank loan system. The government also guarantees equity participation by banks, whose exposure on any single transaction is limited to a mere 15 per cent.[1]

Numerous other industrial support programs exist. They include the Comité interministériel pour l'Aménagement des structures industrielles (CIASI) that expended $400 million over six years; the Comité départemental de financement (CODEFI) ($4.4 million advanced to 220 enterprises since 1974); the CEPME, which coordinates aid at the regional level; the Société de développement régional (SDR), regional development companies that may be subsidized by up to 50 per cent of their investments; and the Industrial Development Institute (IDI) which is a semigovernmental investor in medium-sized firms of whose capital of $200 million the state has contributed one half. A noteworthy program is Société financière internationale (SFI); where, in return for agreeing to invest 80 per cent of their capital in innovating companies, certain private risk companies receive tax advantages and risk insurance of up to 60 per cent of losses. The largest such firm, Sofinnova, is capitalized to the extent of $13 million. Some feeling for the magnitude of official support to industry, *excluding* the large nationalized enterprises, can be obtained by reference to the following reported annual levels of the *principal* industrial aid categories: 1971, $940 million (1971); 1974, $1.3 billion; 1976, $2.1 billion; 1978, $2.2 billion.*[2]

Research and Development

One of the earliest manifestations of state-directed innovation originated in the 1940s in the form of the so-called "letter of agreement" inviting a particular business to produce a product or products deemed of value to the economy. Like so many boosts to industrial development in other countries, the practice flowed from wartime exigencies. In 1972, the government extended the system to induce banking institutions to support particular enterprises; thereby facilitating the granting of bank loans for new ventures, with a government institution underwriting the risk. While the letter of agreement was a general purpose development tool, its actual application was at the microeconomic level. Its flexibility is illustrated by a special arrangement to support firms supplying customers with numerically-controlled machines. A letter of agreement was only issued if, among other things, through the Ministry of Industry and Research, a company could assure the *novelty* of a product or process and its relevance to the objectives of industrial policy. Most significantly, the letter of agreement directed financial aid to the latter part of the innovation cycle, namely, when a firm was on the threshold of production and marketing. Between 1972 and 1975, 43 letters of agreement covered loan guarantees to the value of more than $7 million (1972-75).

In 1978, Crédit moyen terme a l'innovation replaced letters of agreement to promote the development and marketing of wholly new products. The program guarantees bank loans for activities not normally eligible for commercial loans (including licensing and sales promotion). Like its predecessor, the scheme is directed to the latter end of the innovation cycle. Loans amounting to $22 million were guaranteed in 1979. In the same year, the Crédits de politique industrielle (industrial policy loans), which supplement other sources of funds

*These statistics do not include the usual vast expenditures represented by government procurement, including defence contracts, *nor* funds expended on the "grandes entreprises nationales."

and support projects that put new products on the market or introduce new processes, had also been regionalized.

The joint action operations (actions concertées) are another major direct form of intervention. Established to promote research in priority sectors, they draw on financial resources of various ministries for the benefit of public or private research establishments. Private recipients must bear from 25 to 50 per cent of the cost of a joint activity. Once again, the instrument dispensing grants can be directed to support precise or narrow industrial or innovation objectives or particular firms. University, government research facilities and private sector resources are pooled and harnessed for research. The solution to specific technical problems must be within the framework of identified national goals. "The 'actions concertées' are notably intended to promote extensive cooperation among groups of organizations and experts from various fields, between the public and private sectors and also among scientists within committees responsible for program selection and follow up." The program disbursed about $82 million in 1978, and $89 million in 1981. Unlike the letters of agreement, the actions concertées have an impact on the earlier stages of the innovation process, although their flexibility allows their integration with other support measures.*

Front-end innovation is also assisted by a technical research program. The program is aimed at industries with longer-term objectives and assists adaptation to new socioeconomic conditions. Contracts are placed to promote specific innovations. A more substantial instrument, ie., development aid, dispensed low-risk loans to cover up to 50 per cent of the cost of putting an innovation into production. Its primary objective was to benefit large-scale enterprises. In 1972, for example, 64 out of 100 contracts went to firms employing more than 5000 people. The disbursement rate ran above the $100 million per year mark. This program was replaced in July 1979, when the functions and resources of Agence pour la valorisation de la recherche (ANVAR, the national agency for the promotion of research) were substantially enlarged, reflecting the government's increasing accent on the application of research results and particularly new technology. ANVAR's initial budget allowed the expenditure of $110 million on sharing R&D costs with firms and an innovation award involving an automatic reimbursement of 25 per cent of the cost of using an outside laboratory; no limit was placed on the program's total expenditure. In 1982, the budget was raised to

*In 1978, the government introduced a new procedure, contrats de programme. As far as the private sector is concerned, the purpose is to concentrate on one or two enterprises in a sector that has a particular competence. This avoids "too great a scattering of financial support and enables French industry to meet growing international competition in those fields."

$160 million. The offices were decentralized, with 22 regional offices spread throughout France.

It goes without saying that the usual direct *tax deductions* for R&D apply in France. Additional write-offs are available to small and medium-sized firms; in 1980 $25 million of revenue were foregone on this account.

Finally, many agencies assist in *technology transfer*. Some include the centres techniques industriels (cooperative research), regional agencies for scientific and technical information (ARIST), and exhibitions (notably the famous biannual Délégation à l'innovation et la technologie (INNOVA)).

Electronics

Nowhere has the full range of French planning proclivities been better illustrated than in the field of electronics. In 1965 the government introduced the (in)famous Plan calcul (1966-1980), which was a response to the failure of the major French computer firm, Compagnie Bull, after its success in developing Gamma and Gamma 60, two quite advanced computers. Unlike the actions concertées, which, though applying directly to selected firms, was still generally available across sectors, the Plan calcul was aimed directly at the electronic sector with the intention of using direct subsidies not only to develop related technologies, but also, and more particularly, to create a French "national champion" as an instrument of computer policy. The government formed a private company, Compagnie internationale de l'informatique (CII), out of a joint venture among three firms, and gave it an initial grant of $80 million, followed by a new loan in 1971 and access to preferential treatment by way of government procurement and support from nationalized enterprises. By the time CII folded, the government had spent an estimated $125 million on the company. It was then integrated into a European consortium, UNIDATA, a venture costing the French government $130 million for market and development studies and another $50 million in loans. When UNIDATA was abandoned in 1975, a new company, CII-Honeywell Bull, was formed, with 53 per cent French participation. Between 1975 and 1980, government support for CII-Honeywell Bull totalled $522 million, not including state guaranteed purchases of $980 million over four years, or an increase in subsidy if sales fell below the required level. Despite large initial losses and a chequered career, by 1979 CII-Honeywell Bull not only had the highest data processing revenues of any non-American, non-Japanese company, but also, and more significantly, a very substantial share of European markets.

Assessment of the effectiveness of the French government's plans and interventions in the computer industry is outside the scope of this study, particularly with regard to the development of large-scale computers. However, the long-term vulnerability of the French "national champion" is related to a dependency on foreign suppliers of such electronic components as semiconductors. By 1975, this problem was already fully understood, but the main French manufacturer of semiconductors was so weak that CII was obliged to design its equipment around components supplied by Texas Instruments. As soon as the French company was about to bring out 16K chips, the US was ready with a 64K capacity. These lessons were not lost on the French planners.

Mention must also be made of the Plan péri-informatique, introduced in September 1975, for microcomputers. The plan was to assist in forming strong manufacturing core companies in this subsector, reinforcing and complementing the 1975 Plan calcul which allocated different parts of the electronic network to different companies. The government adopted a formula of "contrats de croissance" (development contracts) which permitted several types of existing aid (grants and aids to development) to be used for the benefit of enterprises fulfilling certain conditions with respect to growth potential and defined growth targets. Between 1976 and 1979 growth contracts were negotiated with six companies - Logabax; Transac/Sintra (CGE); Pyrac; Intertechnique/IER; SAT/SAGEM/CSEE and Benson. The Plan péri-informatique awarded $27 million under these contracts. By the end of 1979, according to reports from the Ministry of Industry, the "quasi-totalité" of contract objectives had been reached, with French industry taking 40 per cent of the domestic market in 1978 compared with only 30 per cent in 1974.*

To complete the account of government intervention in computers, it should be noted that because CII was to concentrate on mainframe computers, the government merged former CII activities in minicomputers (existing minicomputer and strong research teams) with an existing Thomson subsidiary to form SEMS, a new Thomson subsidiary. Public aid amounted to 270 million francs over five years. But by September 1981, SEMS was in considerable difficulty because of its failure to produce successors to the minicomputer inherited from CII, or to move into microinformatique. In an effort to survive, the partners were seeking arrangements with foreign companies.

Microelectronics Components

Recognizing the need to develop an independent capability in integrated circuits for the computer industry, the government encouraged the formation of Sescosem, through a merger. The new com-

*Logabax, one of the largest of the core companies, was only saved from collapse by being taken over by Olivetti and Machines Bull in the summer of 1981.

pany, a subsidiary of Thomson, undertook to increase its capital and to manufacture integrated circuits. The state's initial grant to Sescosem amounted to some $4.5 million but losses by the company necessitated continued assistance. Of the $19 million provided to the components sector under the Plan calcul for 1967-71, the largest part would seem to have gone to subsidize this company.

By 1977 Sescosem had failed. Partly as a result of this failure, the government adopted the Plan circuits intégrés, with an allocation of $130 million per year (in constant 1977 dollars) for five years. Various ministries shared the financial burden, with the Department of Industry carrying 48 per cent. The Plan had four objectives:

- to improve and enhance development and production of integrated circuits by French industries;
- to acquire current technology from the US;
- to catch up with other countries by 1983; and
- to put in place the necessary structures and incentives for the utilization of integrated circuits, especially microprocessors.

By the end of 1978, the government had created a Groupement sur les circuits intégrés au silicium under the leadership of the Centre national de la recherche scientifique, which had already been involved in research on electronic components and integrated circuits, and the Centre national d'études de télécommunications (national telecommunications research centre (CNET)), which had embarked upon the establishment of a microelectronics centre at Grenoble. Significantly, the Groupement would work closely with industry as well as the various research institutes and government agencies - one example of the French "network" (filière) approach to officially-supported innovation. Such collaboration would also include a group formed in January 1978 to coordinate microwave research and at least two other groups concerned with the materials, logic and operations connected with "des systèmes de mini et microinformatique."

By 1978, state-supported research into *materials* for microelectronics applications was already noteworthy. The government acknowledged French weakness in the technology of circuit etching and in the ability to simulate and evaluate the performance of silicon components. It also recognized the need to work on most, if not all, of the interrelated activities comprising a self-sufficient national capability in microelectronics, including the need for education and technical training. It launched an extensive analysis of the main areas of future microelectronics applications, which permitted an estimate of the markets for integrated circuits in telecommunications, informatique, automated processes and instrumentation, national defence, and finally, general applications in the field of public consumption (automobiles, information services, medical services and so forth). Given that the government was supporting the necessary research, evaluations and formulations of plans, it recognized that special steps would still be required to translate the national effort into commercial products and services. This would necessitate effective collaboration with the industrial community.

With the onset of the 1980s, the following "ensemble" of core companies offered a basis for an orderly and impressive exploitation of opportunities.*

- The *Thomson-CSF* group whose subsidiary, *Sescosem*, was involved in the production of circuits intégrés bipolaires linéaires professionnels et grand public (linear two-pole integrated circuits for professional or home use). This group had concluded a five-year agreement with Motorola of the US to develop large-scale integrated circuit technology;
- *La Radiotechnique RTC* (Philips) was developing (in Caen) a production facility of integrated circuits for telecommunications;
- *EFCIS* (an affiliate of *Thomson CSF* and a government research laboratory) was also involved with Motorola in circuit production, under licence;
- *Saint-Gobain* collaborated with National Semiconductor of the US in setting up a company, *Eurotechnique*, which would specialize in certain types of integrated circuit production;
- *Matra SA* and *Harris Corporation* of Florida formed a joint venture, *Matra-Harris Semiconductors SA*, which, with the help of a government grant, was to produce integrated circuits at Nantes.

The five members of the "ensemble" shared the total budget of the Plan circuits intégrés. In each case, the agreement setting up the "ensemble" followed the acquisition of specific foreign technology. By 1980, according to industry sources, integrated circuits manufactured in France supplied 60-70 per cent of the French market. However, the production of *metal oxide semiconductor* (MOS) circuits by the "ensemble" was still very small, because two of the MOS companies, Eurotechnique and Matra, only started production at the end of the year. Except in the instance of EFCIS, the companies appeared to be wholly dependent on imported technology in this area. In addition to technical dependence, press reports suggested that the core companies were not internationally competitive.

At the beginning of the 1980s, the government heightened its effort to "francicize" technology, to increase aid to finance new plants, to increase R&D to improve competitiveness, and to provide greater direction for product policy through guaranteed markets. As noted the initial budget for the Plan was $130 million per year (in

*These enterprises exclude the IBM plant in Corbeil-Essones, the Texas Instruments facility in Nice and the Motorola establishment in Toulouse. Interestingly, the French "ensemble", while pointedly excluding American facilities, did include a foreign-controlled enterprise, namely, La Radiotechnique RTC, a subsidiary of Philips.

constant 1977 dollars) for five years. By 1981, the budget was increased to $161 million, with $13 million from the Plan Informatique et de la Société.* By 1985, the Ministry of Post, Telegraph and Telephone (PTT) is expected to purchase semiconductors worth $330 million from the supported companies.

Another major French initiative is the Plan informatique et la société introduced in December 1978 to reinforce national potential in production and commercialization of materials and services (continuing and extending previous plans) with particular emphasis on integrated circuits, remote data handling and data banks, and to develop user demand for data processing, in particular among smaller enterprises, by assisting with applications and diffusing information. An envelope of $120 million (1979) per year for five years, excluding credits to encourage research, was allocated.

The Plan assists four fields: industrial automation, bureautique or office automation, computer-assisted design, and the use of microelectronics in small and medium-size enterprises. The first two were subsequently selected as priority areas for assistance under the Comité d'orientation pour le développement des industries stratégiques (CODIS); however, they continue to be assisted under the Plan, particularly for developing user demand, through, for example, pilot projects. Assistance in the latter two fields includes partial funding for installation of computer-assisted design systems in firms, and for terminals and various remote data processing systems in small and medium-size businesses. Assistance is also given to training and information programs and to pilot projects. The program also provides computers for schools, automation of banking and computerization of the public service.

CODIS was established in October 1979. This action signalled more clearly a distinct shift from a *project-oriented innovation policy* to one aiming more directly at the *creation and support of particular enterprises*. The trend was already evident from the use by government of development contracts to help set up new industries and encourage large industrial groups to diversify into "forward-looking" activities, particularly in sectors such as energy, civil aviation, data processing in space, and telecommunications. CODIS promotes enterprises concerned with, for example, offshore hydrocarbons, robotics, office automation, mass-market electronics, biotechnology, energy-saving equipment. One important feature is its requirement that firms have an international strategy aimed at capturing a significant international market share. The program is designed neither to restructure industries nor to create "national core

*Not included in these figures is the support given to the five groups by state-financed research institutes.

companies" or even to develop technologies as such. Twelve projects, half in the area of office automation covering a total investment of some $2.66 billion, will come within the framework of CODIS by 1985. However, CODIS does not have a separate budget, being only empowered to assemble packages of state aid, tailored to meet the needs of specific projects.

Practice and Implementation

The Investment Climate

The French approach to industrial development has always been unique. In some ways the French government has been more interventionist than even the Japanese. In the latter case, industrial success has been largely associated with an all-pervasive national consensus, so that the role of government, particularly of agencies like MITI, cannot strictly be called interventionist. In France, the central government, including the top bureaucratic echelons, has asserted itself, often in the face of strong political dissent, an inegalitarian social structure and an indifferent public and private business community.[3] This unfavourable environment partly explains why, in France, long periods of comparative national inertia have had to be interrupted by traumatic bouts of leadership. As John Zysman has noted:

> "The alternation of stultifying routine and explosive crisis with a charismatic leader seizing centralized authority to break up social logjams is often described as a fundamental pattern of French politics as well as French organizations."[4]

A general picture emerges of a "fragile social consensus, with antagonisms at all levels" including schisms between politically motivated union leaders and "backward looking managers."[5]

Unless the cultural setting is appreciated, the rather dramatic character of many French interventions may lead one to overrate the overall importance and strength of particular policies and programs. French bureaucracy has been deadly-centralized, but "segmented on both hierarchical and functional lines by rigid rules, and constipated by an active refusal to participate in the organization and by avoidance of face-to-face relationships."[6] When central authorities do intervene, they can do so effectively at the highest levels of decision making, at the level of the Cabinet, the Commissariat du Plan and the Ministry of Finance, by granting or withholding budgetary allocations, awarding jurisdictions and even nationalizing large firms in big, discrete, chunks of activity. More often than not, the authorities have also intervened for political rather than economic reasons, indelibly colouring the resulting activities with political objectives not necessarily compatible with the dictates of the marketplace. At a high level, the French state, *l'état*, has been remote from communities, an independent force in political life, "an instrument of centralizing power, created apart from society."[7]

It would be a mistake to assume, however, that formal centralization at a high level, allowing a remarkable capacity for unified and concerted action at that level, necessarily means a capacity to act in a coordinated and effective manner at lower levels, where decisions have to be further elaborated and implemented. It is relatively easy to allocate capital and to set grand targets, but when it comes to implementation, a formally centralized state may be informally incapacitated, paralyzed by hierarchical and functional barriers.

As for industrial planning, a world of difference exists between state direction of heavy and "captive" industries, like oil, steel and banking - relatively slow-moving industries not exposed to rapid technological change - and state direction of businesses subject to the international competition in high-technology activities such as microelectronics. One would have thought that the state would be capable of at least creating an effective climate for industries and technologies it could not directly manage. Instead, we find that in the end, with all the weapons at its disposal, the government's incursions in the field of computers and electronics have failed to wrench back control of the domestic market from foreign firms, failed to supply critical inputs from state-controlled sources, and failed to assure the necessary markets, both at home and abroad. Granted that the expenditure of vast sums of money on the computer and components schemes did help to create a respectable presence in certain markets and contributed to the strengthening of the necessary "infrastructure" of skills and experience. But, in general, it is hard to find any informed commentator who is not more conscious of failure than success.

Criticism of the bureaucracy is especially sharp in the field of microelectronics policy. Giovanni Dosi notes:

> "The most striking example, not only in semiconductors but generally in electronics, of the inability of European governments to implement an autonomous strategy, is the French case."[8]

Some critics regard this failure as an example of an industrial strategy in conflict with the imperatives of the market, while others argue that it is the fault of incoherent planning, in so far as it conflicts with the strategies of each company. We are reminded of earlier remarks when we also learn that, by contrast, other European countries, with possible exception of the UK, have enjoyed a basic social consensus about the tasks and aims of industrial policies, and that those policies generally work "with the already existing structures and strategies of the companies operating in the field."[9] Such a consensus also prevails in Japan, and, despite the confrontational squabbles and lobbying that comprise American politics, in the US.

Perhaps, from this point of view, it is not surprising that the French have experienced great difficulty in knowing how to deal or work with foreign-owned enterprises. They had barely begun to shift to an acceptance of joint ventures with US and even Japanese firms when the new Mitterrand government's nationalization measures appeared to deal a further blow to a sensitive area of potentially fruitful international business cooperation. Although foreign partners might still be willing to continue their technological and marketing liaisons with French firms, those tied to firms being nationalized were fearful that "state-controlled companies are destined to find themselves paralyzed in a web of government bureaucracy."[10] Yet France needs foreign expertise and resources in electronics more than ever before.

Indigenous criticism of French microelectronics policies has been scathing. In *Mémoires volées*, critics attacked wasted money, ineffective corporate restructurings, "catastrophic results," indifferent and risk-shy but subsidy-gobbling state enterprises, inefficient monopolies, and, above all, a total lack of coordination accompanied by severe bureaucratic infighting at departmental and subdepartmental levels.[11] The authors, so far from advocating deregulation and market-induced remedies, recommended even more extensive intervention, a more complete and "global" strategy with fewer gaps and better coordination. But, ironically, they reserved their strongest vitriol for the bureaucrats - a veritable "vaudeville administratif," unimaginative, incompetent, out of touch with the real world, acting on the spur of the moment, without coherence - a complete contrast to the integrated planning and activities of multinational enterprises. Unfortunately, the French administration was essentially incapable of implementing an integrated strategy, even if one existed. Other critics of the same ilk had surfaced before.[12]

Even after the traumatic new initiatives launched by M. Chevènement, it would be unwise to conclude that French planners and public officials have succeeded in turning over a new leaf. Some critics remarked that a much-vaunted 1982 Great Conference on Research, which culminated nationwide consultations, rarely went beyond the self-serving interests of the public research bureaucracy, and virtually ignored the industrial sector. Labour union participation was "uneven"; and public service unions showed little interest in proposals to increase the mobility of government-employed scientists and engineers.

Terms and Conditions

One of the first microeconomics assistance schemes for innovation in France was the Aide au développement, which provided 50 per cent of the cost of developing prototypes, or of improving new products or processes. The aim of the program was flexible support, in the belief that "French firms need to be taken by the hand and shown the value of being innovative."[13] Applicants received a list of criteria, covering the usual factors of novelty, probability of success, market potential, profitability, the firm's abilities and resources, relative risk size, and conformity with French industrial policy and priorities. In practice, the factors weighing most heavily included self-sufficiency with respect to imports, inward technology transfer, originality of a product or service and strengthening the competitiveness of French industry.[14] Aide au développement emphasized helping firms to be internationally competitive, underwriting threshold costs and sharing in risks too heavy for the firm in question. Electrotechnology was one of the favourites on the government's list of priority areas.

Among the concrete conditions of the program contract, the payment and repayment terms were, of course, central. Firms were required to contribute 50 per cent of the project cost and repay the government contribution in the event of "success." The rate of repayment was an agreed percentage of the gross sales resulting from the project, anywhere from 2 to 10 per cent. After some years, the scheme levied interest charges on the loans. Before that, successful projects also meant an obligation to pay the government a bonus of 20 per cent. An agreement between the parties that a project was a failure had to be reached within ten years. It is worth noting that the definition of success or failure was a flexible feature of the scheme.

The next most important issue was the rights to the developed technology. The firm retained the proprietary interest, but paid the government 25 to 50 per cent of the proceeds of any sale or licensing of patents.

Additionality

The most intractable problem for governments, and one demanding much sophistication, is the so-called question of "additionality" or "displacement." In theory, governments are only prepared to contribute risk money for projects that firms would not have undertaken otherwise, or, in some cases, would not have been able to expedite. The problem is related to the reluctance of firms to disclose all their important projects, if only to protect commercial secrets. In France, firms initially took the Aide au développement program at face value and only put forward truly speculative projects quite outside their main field of activity. But as soon as the responsible ministries became more averse to risk and began to favour ideas that were "central to the firm's traditional business," firms no longer presented riskier ideas, but tended to start from the top with projects, which, by definition, they would have been tempted, or may even have already decided, to pursue in any event.[15]

From the government's point of view, particularly if a project was very large or subject to public announcements, it was politically important that a subsidized project did not fail. From the firm's point of view, government funding simply helped to free resources for projects lower down on its list, or indeed, for other investments that had no connection with R&D. "Displacement" of this kind prompted senior officials to advocate that large firms in particular should simply be given an annual financial allocation to improve the firm's cash flow at the "front end." Front-end money was important to any sophisticated manager who knew about discounted cash flows.

The larger the firm, the larger the "portfolio" of candidate projects for innovation, and the greater the probability that "displacement" would take place among such projects. The smaller the firm, the more likely that any project put forward for government support might not be undertaken without such support. *Prima facie*, this would argue for a support system of direct grants for specific projects proposed by small firms, but a more general "horizontal" cash-flow generating mechanism for large firms, such as simple tax incentives tied to total expenditures. In the case of a large firm, the only effective way public officials might know they were not squandering public money would be if they had knowledge of *all* the projects on a company's list. This might be feasible with government-controlled companies; but it would be much more difficult, if not impossible, for government to secure that degree of disclosure and cooperation from independent firms.

Success or Failure

A fairly close working relationship exists between some large firms and French officials. When such is the case, both the firm and the government might have a natural interest in tying a grant to an important project that is unlikely to fail, but also most likely to have been undertaken with or without government support. Both parties would understand, however, that the government subsidy was intended to promote another, riskier, project lower down on the company's ranked list.[16]

Even so, such an arrangement has an interesting corollary, connected with, and explaining a unique French practice requiring some companies to repay a government grant if a particular project *fails*. Such a practice contravenes all received wisdom about repayment obligations; invariably, in all countries, repayment obligations are tied to project success, not failure. This condition may, however, be the logical outcome of choosing a project certain to succeed. If this kind of operation is indeed feasible, all parties may gain:

i) it places no legal obligation on a company to repay a grant used for a formally unidentified project, *even in case of success*;
ii) public funds support a truly risky project;
iii) and the company is obliged to make sure that its most favoured project will succeed, on pain of penalty.

On the other hand, the government gathers the political dividends of supporting a major successful advance whose prospects of failure are considerably reduced; the legendary reluctance of bureaucrats to incur substantial risks is overcome.

These rather unusual repayment provisions are not confined to instances where the very large firms and bureaucrats meet to survey corporate plans, and where "displacement" can be more easily "controlled." A very senior spokesman for a responsible ministry indicated in an interview that whenever the government discusses affairs with companies, not necessarily large ones, the government tries to impose contract conditions clearly postulating successful outcomes.

> "If a company is not certain of success, it will not accept money that is extended on the basis that, if a project fails, the money will be refundable. It is only in certain cases that the state provides for the repayment of funds where projects are successful, as distinct from cases where refunds have to be made because a project fails. The repayment in cases of success is tied to projects where conditions are particularly difficult. Those are conditions under which no industry may want to venture forth."[17]

The practical consequences of this approach call for careful thought. There could be quite different impacts on risk-prone small firms and more resourceful large firms depending on how "success" or "failure" is determined. An interesting range of related costs and benefits presents itself, even at a national level. On the cost side, many of the larger firms that ought to be taking innovative risks, are perhaps not prepared to move on anything unless they first see "the colour of the government's money." Hence a further allegation that some of those most favoured "national champions" are effectively only putting 20 per cent of their own money at risk. The French experience has shown how government largesse can change business attitudes for the worse,[18] and that the contribution firms make from their own resources has been pitiful.[19] These are consequences that one would expect to find in any event in markets that may have been overprotected for too long;[20] inadequate self-financing has long been a chronic problem.[21]

The unusual success or failure formula is not confined to a few cases where displacement has been negotiated. Applicant firms in

France rarely, if ever, give the government a shopping list of all intended or possible projects partly because the government has only been interested in projects that are "real and seriously proposed."[22] It is not, of course, difficult to understand the sense of tying repayment provisions to success where the risks are indeed quite high. But the failure provision may make more sense where the grant or loan relates primarily to *extraneous* public policy objectives, which may go well beyond the usual concern for technical innovation in a particular transaction.

Two Levels of Agreement

Some evidence of such extraneous factors can be garnered from the practice of having *two* levels of agreement. The more customary level is a legally binding contract governing a particular project. Often, however, the parties may have made a prior, umbrella agreement, which is not legally binding, but more in the nature of a general understanding (une convention). The umbrella agreement arises after a firm has presented the government with a comprehensive dossier* containing an outline of strategic, technical, production, product, R&D, financial and investment-related information, including information about the formation of subsidiaries and partnerships and licensing arrangements. The dossier also covers plans to create subsidiaries abroad or to enter into joint ventures to capture markets, especially in the US and Japan. On the company's part there is an understanding that it will create jobs, increase sales, boost exports and finance its activity in an agreed manner, and if the dossier touches on "completely new"† product or process developments and technology transfer, it would include those aspects as well. The dossier itself must be accepted by various ministries because of their possible role in granting approvals for joint ventures, or in releasing part of the funds that might eventually flow to the applicant firm.

Approval Processes

The two-level agreement practice, at least with the large firms, is intimately connected with a time-honoured approval process, in which many government agencies have always participated. The Aide au développement provides a good example of this process. First, an *independent* expert from government or the universities, and only rarely from the private sector, provided a technical evaluation. This expert, who could be freer and more outspoken than formal commit-

*Not everyone is impressed by the quality of the dossier. Their lack of even the most elementary cash flow analyses demonstrates their crudeness.[23]

†The inference is that completely new developments might not always be the central issue, further evidence of a rather strange approach to the success or failure criteria for repayment obligations.

tee members, especially since an oral report could be submitted, replaced a former system of technical review committees. Next, the Crédit national - again an expert function - gave a financial review. The Science Ministry would then transmit the two sets of reports and its own recommendations to a branch of the Ministry of Finance for deliberation by a representative committee of up to ten people. Three months might elapse before a contract was finally signed. Payment was in one lump sum - usually long after the project was on its way. Each year the recipient would file a progress report and, until the firm repaid the government loan, a detailed financial account of sales related to the project.

Not surprisingly, companies complained about the costliness of the program in terms of demands on their time, estimated by one small business spokesman at 20 per cent of the value of the financial assistance. But some firms, as in other countries, felt that they profited from the experience and the discipline of preparing the dossier; they actually used the application procedure to secure a thorough external evaluation of their business plans. This contingency might be a significant unrecognized benefit of bureaucratic services in any country!

Around 60 per cent of the money went to eight conglomerates, four of them in electronics. The government adopted a special procedure for dealing with them. The Science Ministry met with the president and senior officers of the firm once a year to assess the firm's *overall* R&D program. Then a two-level evaluation took place. At the annual review, the firm placed its entire R&D portfolio on the table, or as much as it was prepared to disclose. The company would identify the projects it planned to bring forward for assistance, and the Crédit national would prepare a single financial review of the firm and its plans for a year at a time. This procedure enabled the ministry to plan its overall financial commitments, and, inevitably, this "allocation" amounted to a "set-aside" for the benefit of the firm. It also gave the firm an opportunity to learn from the ministry about the government's longer-term policy goals, and the most-favoured types of technological research. At the secondary review level, the firm would, in any event, have to bring back each individual project for normal review by the responsible agencies.

This process is distinctly horizontal, requiring extensive coordination. Various sources of credits from different parts of government under, for example, research in general, or electronic development, regional expansion, industrial development, and even defence must be lined up. Would this process occur if all industrial development financing was contained in a single program handled by a single ministry?

Apart from serving as a reference point or basis for specific project agreements, the dossier serves the useful purpose of needing to be updated every year, which justifies an annual meeting between government officials and the firm. In fact, companies involved in one or another "plan" must meet with the government at least twice a year, for the purpose of reviewing their progress. When a particular project is off and running, government representatives may also visit companies once or twice a month; in theory, the visits are unannounced. Such visits allow government officials to follow up on the information the firm disclosed about licensing agreements (duration, royalty rates, payments, ownerships rights). In some cases, the officials "want to know what passed between the parties" since the last visit.[24] When licensing terms change, the firm must inform the government; this formality pertains to such normal transactions as second-sourcing agreements among firms, which are usually on a product-by-product basis.

Flexibility

The approval and negotiation processes contain some curious contradictions. On the one hand, even before the Mitterrand government, a school of thought in some ministries maintained that the approval procedures were too loose and unspecific, that firms had been given too much discretion in determining their own process and product priorities. As one senior up-and-coming official expressed it in an interview: "Mistakes were made in the past, because firms were allowed to do what they thought best." The contracts were too vague, said another official, because the government "covered many sectors in too nonspecific a way." This more hardnosed attitude became particularly evident after the election of the Mitterrand government in ministries that were large purchasers of products and components. One official in such a ministry asserted that many suppliers "would not always promote or pursue the best technological product and the results of the firm's work were not available to others even though the state had paid for a development." Other domestic firms did not have adequate access to such know-how.

For these and other reasons, the government was beginning to scrutinize contracts between equipment suppliers to the state and their own subsuppliers of, for example, integrated circuits. The state wanted to ensure that the subcontract terms were not inconsistent with the main supply contract. It was thought that if the state had paid for a development, other national manufacturers who had not received state assistance ought to be able to benefit from the know-how because, "the country does not want to pay twice."[25] Also, these companies would not have to pay royalties to the main contractor, at least not in the internal domestic market. Moreover, the state would write product specifications to discourage firms from designing equipment exclusively suited to the French market. Instituting new standards for equipment could also serve as a useful tool to select and influence supplying firms.

On the other hand, the French government, unlike the governments of most other countries whose financial support varied considerably was not flexible with respect to the percentage level of loans and grants. In France, loans and grants were usually on a 50-50 sharing basis. The state would contribute 100 per cent of project costs, in exceptional instances, if a very "special interest" within a ministry existed. The government might have a particular interest in a specific product or component in the military field, for example, or a specific integrated circuit for the national telephone system, or the government might intend to capture the results of research entirely for its own use. But even in the latter case, a full-cost contribution would be unlikely unless the recipient was fully French-owned. Essentially, French authorities were not flexible enough to vary conditions and contract terms in proportion to fluctuating levels of risk and varying percentages of government funding.

Foreign Firms

To a certain degree, government is realistic in its treatment of foreign firms. A foreign firm seldom receives more than the standard 50 per cent grant or loan, because bureaucrats are well aware that "under those circumstances the transfer of technology cannot be fully controlled."[26] In electronics, some foreign firms are "trusted" more than others, including subsidiaries of two well-known Dutch and Belgian companies.

The government is aware that foreign firms would not submit to the probing into their affairs sustained by the "national champions;" namely, the six companies that a leaked internal report claimed received fully 50 per cent of all government contributions over a ten-year period. Maintaining an arm's length relationship, the government has not pressed even a "most favoured" foreign firm to diversify, being satisfied merely to treat it as a reliable up-stream supplier of technology, and confining tough technical demands to government supply contracts. Such a foreign company must inform the government of the "general nature of the flows of technology" within its multinational group.[27] And although it must inform the government of any specific licensing agreement related to a government contract, it is not clear that the company ever requires actual permission to enter into licensing arrangements.[28]

The state's ambivalance towards foreign firms is preserved because the real impact of government support on their corporate performance and behaviour is unclear. An arm's length relationship may be maintained because most, if not all, funding is project-related and the government, even with a domestic national champion, at least at the umbrella level, is "not allowed" to prescribe or to choose projects from the company's list. Later on, individual client ministries may do so. Because the company has the responsibility of submitting the original list, it is able in practice to carve out only the kinds of business it is prepared to disclose. So it transpires that the innovation support system is not necessarily driven by a guided technological policy when government programs are actually delivered (one possible reason for the government's renewed interest in becoming "more interventionist.") At least a couple of foreign firms held that the government was not interested in managing their performance, only in their being competitive. According to a spokesman for one foreign-owned company: "It is up to the company to state its targets and priorities, and if your plans are sensible, the government will accept your word."

Selection Criteria

At least at the first level of assessment, the government is not really interested in *what* product the company makes. The company's initial list of projects must relate to expected business objectives measured in terms of sales of products manufactured in France. This does not deny that technical specificity governs the decisions of individual ministries at a later stage of the process. However, at the first stage the government emphasizes corporate competitiveness, measured strictly in commercial terms.* "The aim," said a *technical* bureaucrat, "is to help firms be profitable." Competitiveness is also measured by the technical excellence of the firm, and that, in turn, is measured by the degree of integration and miniaturization of products achieved, and the extent to which it succeeds in integrating software into hardware. Thus, technical targets are discussed at the annual meetings between state and firm representatives.

The prominence of the sales criterion, while superficially recognizing the importance of market-orientation in business decisions, often results in companies putting all their energies into products bound to achieve sales in the shorter run, at the expense of riskier, long-term innovation. The neglect of innovation happens particularly when subsidies are repayable in the event of failure. Worse, overemphasis on sales may well invite extraordinary temptations to "fiddle the accounts."

Signs of imaginative industrial development planning and implementation of programs on the part of the bureaucrats are various. An otherwise rather critical observer, who gives advice to the government at a high level, spoke of an emerging tendency on the part of

*In the field of electronics, the government does apply direct criteria that may go beyond the mere measurement of related sales, as in the case of the program for very large integrated circuits (VLSI), which is tied to national objectives.

the state to spread its money over several firms in the full expectation that one or more of them would fail.[29] As far as the domestic market is concerned, the state looks to support at least two competitive firms. But with respect to competing in the international market, it tries to foster cooperation and concentration of effort among firms.

Another major selection criterion is the company's potential contribution to the creation of a strong domestic base. There is a renewed emphasis on "developing from a national market" because "protectionism is absolutely necessary for every country that is not American."[30] But how does government create a strong domestic base? First, through imaginative sourcing; and second, by pushing companies to make a special effort. Thus, under CODIS the government approached firms to entice them into the field of robotics and offshore technology, because, according to a civil servant, in those fields one cannot rely on voluntary procedures.

Unfortunately, pushing firms does not always produce the desired effect. "The more one pushes a business, the lazier it becomes," lamented a senior bureaucrat. No secret is made of the fact that one of the national champions, which has learned to live with its head in the public trough, is considered to be totally dependent on largesse, even though it has been "full of good ideas."[31] One firm failed miserably to move into the consumer product field despite the promise of a sustained internal cash flow such a move would generate. This was unlike so many Japanese companies, which, through a system of cross-financing, boosted themselves into cash-generating consumer product sales. Because of the "laziness" of French companies, France has no versatile and integrated firms equivalent to Siemens of West Germany. French companies are all more or less specialized - at least in electronics. The success of a few electronic firms like Matra is said to be due to their consciousness of the value of synergy, the cross-fertilization that is possible within a diversified group.

One rather daring example of imaginative state intervention is a ministry that believes in encouraging spin-offs; it will even attempt to find frustrated individuals *inside* organizations and firms who may be tempted to go out and form their own firms. The same ministry claims to have been farsighted enough to encourage French electronic firms to start buying out small high technology companies in the US. However, the above examples are not necessarily the rule. One spokesman felt that much more could be done for small firms if state-controlled banking, insurance and pension funds were channeled into entrepreneurial ventures. And an otherwise conservative civil servant in a conservative ministry complained bitterly that in high technology areas not even the state-controlled banks have pulled their weight.

Overview and Prospect

For at least two decades, the French government has left no stone unturned in its relentless pursuit of national excellence in the field of electronics. The new Mitterrand administration, which undertook to lift the entire national R&D effort to higher levels, including the institution of extraordinary measures to advance the cause of microelectronics and the new information technologies, reaffirmed and expanded this commitment.

President Mitterrand began his program by introducing M. Chevènement, as the champion of the future (Avocat de l'avenir). He organized a national colloquium in January 1982 as the climax to a remarkable series of 33 regional meetings. The meetings were held to help plot the course for future science and technology policy, with the objective of lifting R&D to 2.5 per cent of GNP by 1985. This colloquium identified microelectronics, "informatique" and biotechnology as major fields to be mastered in order to raise France to the status of a first-rate competitor. A new budget provided for a 29 per cent increase of government spending on R&D. The new government then created a Centre for Studies on Science and Advanced Technologies (CASTA) with a mandate to concentrate on "missed, or botched, industrial opportunities." It also aimed to "wipe out the country's trade deficit in the components sector," to increase planned turnover of state-backed circuits from $110 million to $900 million by 1986 and it approved a new initial subsidy of $106 million for microelectronics research for the current year, which would accompany an even greater concentration of the industry.[32] After the new nationalizations of 1982, the state share of the computer and office equipment industry increased to 36 per cent and of the electronics industry to 44 per cent. Quite simply, "Mitterrand has decided that if France cannot master the microprocessor revolution it will be overwhelmed."[33]

Although half-way through 1982 a government report expressed doubt about the financial capability of the French government to implement its grand strategy for the new technologies,[34] no evidence emerged of a flagging commitment to the new national goals. Indeed, M. Chevènement stuck to his objective of transforming a trade deficit of $330 million in electronics into a trade surplus of $6700 million by 1990. However, the centralized French industrial development system is prone to fail in its primary objective, namely, in the efficient and effective coordination of state-supplied aid. Respectable authorities, both foreign and domestic, have repeatedly asserted that French industrial and technological policy has failed in its *implementation* of grandiose and expensive "plans" because top-level national and bureaucratic coordination has not been matched by effective coordination at lower levels. In other words, France is not Japan. The state has not been able to put together its own act in the meeting-place with other integrated actors, least of all in an area of technology like microelectronics, which is not only integrative by nature but also part of a footloose international market.

"The French strategy of state control only works when the international situation allows it," a report prepared for the Dutch government noted.[35] As early as 1971, the OECD was convinced that "bureaucratization is incompatible with the increasing interconnectedness of policy sectors." At least one commentator regarded the problem of coping with multinational enterprises in France as signalling the subordination of the state to corporate priorities.[37] In such conditions, if the state cannot maintain a monolithic character through to the implementation stage of its policies and plans, the next best alternative may well be the extreme opposite – functional decentralization and flexibility.

The French bureaucratic model is the antithesis of such a solution. The most realistic alternative for the French is probably the one already attempted; namely, the two-stage process of overall corporate plan assessment and agreement, followed by specific contracts at the individual project level. But even the degree of flexibility inherent in that procedure is still constrained by the cultural and institutional framework. The relatively remarkable flexibility of a negotiation process with large firms, which allows the "displacement effect" referred to before, is largely confined to interactions with trusted national champions. But if France must depend to a high degree on foreign technology, the country needs a constructive method of dealing with multinational enterprises. No evidence exists, however, of any comparable methods of reaching accommodation with the footloose players. Rather, a "stalemate between government and companies" has continued.[38]

Failure to form constructive relationships with multinational enterprises is especially serious in the field of microelectronics where the increasing capital and research intensity has produced more and more "backward and forward" integration in various countries, and a more pronounced reliance on large firms. That theme brings us back once again to the question of the competence of the bureaucrats themselves in the process of negotiating and bargaining with large firms, especially multinational enterprises, even though, at the *technical* level, the responsible officials seem knowledgeable and sophisticated.

From the point of view of the analyst, one also has to record that among European administrations, the French system is the most secretive.[39] Many large industrial credits, for example, are never made public; vital public statistics, even in the area of health and welfare, are either inaccessible or nonexistent. To secretiveness, some would also add deviousness, a quality inferred from an official memorandum about an "act of safeguarding the appearances of a purely private solution, when it is an artifice since the beginning."[40] But when all is said and done, the overriding irony of the French delivery system for innovation is the most seriously-voiced complaint about its "total lack of coordination" and "the incoherence of [its] industrial policy."[41]

V. West Germany

National Commitment

Industrial Support

West German support for industrial investment and innovation is not only extensive, but also broadly based - "pluri-instrumental," in the words of the OECD. The government has increasingly complemented "climate measures" with various direct forms of intervention. Further, the traditional postwar German policy of promoting free markets may gradually give way to policies that leave individual sectors and firms to establish their own investment priorities within a framework of horizontal, macroeconomic government policies.

After World War II, the West German government's broadly conceived incentive programs addressed regional underdevelopment (mainly along the eastern border) by attempting to restructure traditional, heavy industries, to promote smaller and medium-sized enterprises, and to respond to social concerns. The emphasis began to shift from assistance for the mere maintenance of enterprises to an interest in promoting productivity and adjustment, particularly in view of the high wage structure in industry. Initially, the government did not even conceive of investment assistance sectorally, let alone on a firm-by-firm basis. The first time the federal government helped a particular industry was in 1976, when it provided marketing aid for the development of the VFW 614 aircraft. Other exceptions occurred in the data processing industry. Between 1976 and 1979, the government supported this industry's R&D to the tune of $285 million, and the application of data processing in industry to the extent of $288 million. During the same period, it also gave substantial support to various job creation projects in lagging sectors.

Direct federal financial assistance to industry increased from $874 million in 1977 to $2600 million in 1980. To these figures must be added substantial federal and state incentives by way of tax revenues foregone, which amounted to $6.3 billion in 1980. In the same year, measures to promote productivity and adjustment cost $2.45 billion. At the state level, direct financial assistance reached $590 million in 1976. All in all, a shift from tax-based to direct financial aid became most pronounced from 1973 to 1979, when the contribution of the latter rose from 17 per cent to 33 per cent of the total federal and state financial assistance to industry. At the same time, industry benefited from vast programs to improve the general economic infrastructure (a transport system, water management, residential amenities and energy supply); plans to commit $7300 million for this purpose were unveiled in 1977.

The German approach to industrial support has been consistently comprehensive. "Global," according to the OECD, "the effectiveness of measures depends on their interplay with other factors and measures ... the general effectiveness can only be measured by the final outcome of the whole policy."[1] The measures are also supposed to be stable; their relatively long planning horizons result in not too many incentive schemes being terminated, contributing further to the cumulative nature and impact of public policies.

Technological Innovation

The infrastructure for technological innovation has been immensely expanded by the presence of an extensive network of large research centres, including universities, which although having a pronounced long-term commitment to untrammelled basic research, are nevertheless oriented to broad research priority areas. A Framework Agreement on Promoting Research (1975) enables federal and state governments to coordinate their efforts with the German Research Society (DFG), the Max-Planck Society (MPG) and ten "supra-regional" bodies. Total expenditure on "all branches of science" reached $23 000 million in 1978, of which governments contributed 62 per cent and the private sector 38 per cent. Expenditure on R&D reached $17 300 million in that year, 50 per cent of which came from the private sector; 63 per cent of the total was spent by business enterprises and on joint business-research institute projects. In 1981, total R&D expenditures increased to $22 billion.

Along with the jealous safeguarding of the independence of Germany's basic research capability, an equally strong commitment to applied research has developed, dating back to the establishment in 1949 of the Fraunhofer Society for the Promotion of Applied Research (FhG). In 1978 its total budget was $96 million. By 1980, the Society controlled 25 research institutes which specialize in R&D services, notably through external contracts. The Society provides technological solutions to concrete problems of specific client firms, and depends for 40 per cent of its funds on the powerful Ministry for Research and Technology (BMFT), which was established in 1972 and whose R&D budget now exceeds all R&D support dispensed by the Ministry of Economic Affairs (BMWI). The Ministry of Defence, the Länder* and firms for which contracted work is undertaken provide the FhG with the remaining 60 per cent of its funds. While the FhG directs its services to the needs of specific clients, each of its own institutes specializes in a particular technological field; so coordinated work in various institutes can be produced for the benefit of firms whose problems involve more than one field of technology. Quite clearly, the emphasis on the need to *coordinate* public support for technological innovation is one of the main pieces of evidence of the government's growing awareness of the role of technological innovation as a stimulant to growth. This is especially true of "generic" technologies, such as microelectronics and biotechnology.

The emergence of the BMFT represented the institutionalization of a new interventionist philosophy:

> "The deliberate decision by the government to use massive R&D support could only have been accomplished by major institutional restructuring representing a fundamental break with the free market tradition .... The new Ministry would wield an increasing array of structural and sector-selective programs designed to direct industrial technological development along determined pathways."[2]

This description is matched by a paper, "Federal Science and Technology Policy as a Battery of Instruments for Industrial Policy and Change," delivered by Dr. Josef Rembser of the BMFT in October 1979. Rembser stressed that this,

> "battery of instruments [gave] preference to the promotion of concrete programmes and projects ('direct promotion') rather than granting funds on a broad, uniform basis for R&D costs incurred by enterprises (expenditure-related promotion). As a result, industrial R&D projects are supported by grants if they comply with the goals and conditions of published programmes."[3]

Consequently, the BMFT's budget is highly explicit. Even as early as 1977, the budget allocated specific sums to such key technologies as optics, metrology, chemicals, electronic components, data processing, space research, and telecommunications. The orientation of support to tasks that would *not* be initiated without government intervention results in a focus on "extremely costly projects whose success in the market can be expected only in the long term."[4] Logically this "leads to the fact that big enterprises or consortia of such large firms are commonly those carrying out the R&D."[5] In

*Provinces or states.

1977, for example, BMFT support for large-scale projects accounted for 50 per cent of its funds. The main emphasis was not so much on ongoing R&D, but *future-oriented* areas.

Small and medium-sized firms benefit more directly from a complementary program administered by the Ministry of Economic Affairs (BMWI) and directed to the Cooperative Group for Industrial Research (AIF). Again, the program's design is logical, relating to the innovative behaviour of smaller firms. Because R&D in such firms is integrated with the production process far more than in big enterprises with their specialized departments, it is neither continuous nor broad, and often the same people are involved in various aspects of the business. Direct grants for a firm's own R&D activities would not cover the entire innovation process and may, therefore, be inadequate. Consequently, the AIF program promotes *cooperative* industrial research, essentially pooling the inadequate R&D funds of many firms into large research association budgets. Unlike the FhG, the AIF pursues general technological advances useful to the solution of commonly held industrial problems. While any specific institute of the AIF is concerned with the many technologies of a single industry, or related industries, an institute of the FhG deals with a single technological field common to many industries.

It is not our purpose to provide an exhaustive overview of a system that has been described as one of the world's most elaborate for scientific and technical support of the commercial sector. But it is necessary to draw attention to its comprehensiveness and its growing commitment to sector and firm-selectivity, as well as its deliberate emphasis on cultivating excellence in key technology areas. Specific innovation support measures are complemented by general innovation support programs, such as the Federal German Venture Capital Company founded in 1975, the capital grants provided under the Investment Allowance Act of 1979, the accelerated depreciation allowances, and extensive information and counselling services.

In 1979, subsidies based on the employment of R&D personnel in industry amounted to $191 million through the BMWI and $192 million through the BMFT. However, an interesting development has occurred with respect to the ratio of "direct" to "indirect" support measures administered by the BMFT ("direct" support being defined as consisting of investment grants). That ratio fell from 1:14 in 1976 to close to 1:3 in 1980.

To conclude, it is instructive to examine in a little more detail the break-down of the total public and private R&D "budget" in West Germany in 1979 - an impressive sum of no less than $17 billion. The German Länder and local governments contributed $3.7 billion, the federal government $6.4 billion, and the private business sector $10 220 million.

Electronics

Electronics is most prominent among the key technologies being promoted by governments in West Germany. "If such technologies are not mastered, the result in the long run is that market shares are lost, production drops and the number of jobs is reduced," Rembser has laconically observed.[6] In the early 1970s, the BMFT had already identified the application of electronic components and information technology as priority areas. In 1978 and 1979, the federal government allocated $547 million (1978-79) for R&D in information technologies and technical communications; $629 million in electronics and other key technologies; and $747 million (1978-79) in space research and space technology.

A deep awareness of the opportunities and threats presented by advances in electronics technology existed throughout the country. The FhG medium-term program supported information processing and solid-state electronics at the rate of $18 million in 1978; $26 million in 1979; $28 million in 1980; and $31 million in 1981.[7] In 1977 the federal government undertook a special survey of future needs in key sectors. In January 1979, approval was given for a five-year R&D scheme costing $335 million, for technical communications. But by August 1979, it transpired that the 1980 budget for information technologies alone would be $370 million, which would be part of a new overall fund, foreshadowed earlier, of not less than $1900 million in total for the period 1978 to 1982.[8]

Microelectronics

West Germans who are concerned with industrial development recognize microelectronics as a key, generic technology of the future. Even at the commencement of the Electronics Components Program (1974-1978), attention was focussed upon integrated circuits and semiconductor components. As the 1980 *Sixth Report on Research* states bluntly:

> "There is no alternative to the use of this technology. Those sectors and enterprises that are too late in applying the new information modules in manufacturing and incorporating them into their products forfeit their competitiveness ... . We cannot yet assess the full significance of those innovations emerging in the wake of microelectronics ... ."[9]

Later on, with respect to mechanical and production engineering the *Sixth Report* reiterates:

> "only those with an expert knowledge of those subjects will be able, in the longer term, to plan and export up-to-date production facilities ... manufacturing techniques which incorporate integrated information techniques must enjoy priority in our future R&D efforts."[10]

The Report advised that West Germany would have to build on the results of previous interventions in the computer industry, claimed that government support enabled leading German firms in the large computer field to increase their share of the German market to 20 per cent in 1978, and referred to the establishment by governments of 105 research groups and 14 professorships in computer science. The Report made clear that by the end of the 1970s, the country was already the largest European market for information technology products and services, with twice as many computers as the UK, thanks partly to substantial government support.

The interaction among the various components of computing and communication technologies and the emerging importance of *systems* characteristics, involving all kinds of linkages across technologies, services, production processes and end products was analyzed at length. To underline the commercial significance of the microelectronics revolution, the Report discussed the impact of a new flat semiconductor television screen on the world market for teletubes, which, by 1974, had already amounted to $3400 million.

The German government, conscious "that those ... who take timely steps to acquire command of the new techniques will remain competitive ..." launched a substantial promotional program emphasizing the manufacturing of basic components, LSIs and VLSIs.[11]

The vulnerability of small and medium-sized firms to the competition from microelectronics, in particular, was well understood. Therefore in 1978, a *VDI Technology Centre* for the application of microprocessor techniques was set up in Berlin, which, in cooperation with the FhG, would hold seminars, provide "concrete guidance" on business problems and support industrial development projects covering a wide spectrum of uses "beginning with electronic clocks and domestic appliances and extending to mensuration, guidance and control techniques."[12]

Government support for space research and technology and aviation, to mention only two other fields, included similar initiatives. In the summer of 1979, the federal Minister for Research and Technology brought together representatives of government, industry, labour and the science community to deliberate on the subject of microelectronics, in a "Dialogue on Technology Policy," which was resumed later that year.

Practice and Implementation

The Investment Climate

Of the large European countries in whose policies towards the promotion of high technology, notably microelectronics, we are most interested, the Federal Republic of Germany is at one end of the interventionist spectrum. West Germany is also the least secretive about these matters. Here, as in the case of France and the UK, one cannot divorce a meaningful analysis of policies and procedures from the country's broader historical and cultural setting.

Germany's traumatic encounter with fascism gave rise to a constitution under which the division of powers and the desired checks and balances correlate, both functionally and geographically, with a remarkable dispersal of the instruments of state intervention in education, science, technology and industry. The resulting matrix of actors and activities endowed the German "model" for innovation support with almost elegant proportions; it is a system containing a clearly defined separation of nevertheless complementary vertical and horizontal policy instruments. The most notable example of such a matrix is the respective roles of, and the differences between, the FhG and its institutes on the one hand, and the AIF on the other.* Coupled with the fact that the business community shoulders so much of the industrial R&D effort, the resulting pattern can hardly be qualified as one of strong direct state intervention.

Besides, the federal government in Bonn plays a relatively small central role, being divided between the differing mandates and operating methods of the BMFT and BMWI, respectively. West Germany is not only a federation in theory, but also in fact. Industrial and technological development take place at all levels and in all functions. In Germany there is no short cut to effectiveness and efficiency; no quick fix. Excellence is achieved from the bottom up, even where it may have to be inspired from the top. Certainly, West Germans will deny that performance can be induced from the top.

The relative weaknesses of even such horizontal policy measures as tax incentives shows how nonintensive the federal presence has been. But how can German firms afford to carry so much of their R&D cost burden, if, as it appears, only about 10 per cent of a typical large firm's R&D budget and 20 per cent of small and medium-sized enterprises comes from governments? After the usual straight tax deduction of R&D expenses, there are no remarkable R&D tax incentives. A special provision allows a premium of only 7.5 per cent of expenditures on capital investments for R&D (buildings and equipment), although since 1978, a sliding scale ensures that smaller firms can receive up to a maximum of 20 per cent (not exceeding $300 000) and that their acquisitions of intangible assets (patents and licences) will be eligible. Moreoever, large firms do not qualify for the small-firm special R&D staff expenditure grant introduced in 1978.

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*See pages 62-64.

One example of the social consensus towards the treatment of the private sector is the attitude to patent rights, ensuing from government-supported R&D, enjoyed by private enterprises. Germans generally accept that the gains of public intervention may be appropriated by the private sector. However, the government tries consistently to involve trade unions in the affairs of companies and pays union personnel to study advanced technologies, such as microelectronics, reasoning that an informed work force increases learning opportunities for management. Workers may even goad laggard employers to update processes and products. In addition to these elements of public policy is a growing willingness by governments to permit a more honest evaluation of government programs by relatively independent organizations - even at government expense.

Organizational Structures

The matrix approach ensures that vertically functioning ministries, which may tend to become the captives of their own clientele, are counterbalanced by the horizontal function of the BMFT, even though this ministry does not have a legally enforceable mandate. This functional tension within the system is complemented by an equally useful tension between the BMFT and BMWI; most BMFT branches have their mirror images within the BMWI. But this system does not have the shortcircuiting or fusing characteristics of MITI - the linchpin in a quite different industrial culture. However, like MITI, German programs and agencies are continuous and stable. Older programs are seldom cancelled, and officials tend to stay in their posts for a considerable time.

The German system is marked by competition and contention among interest groups at all levels of society within a framework in which tensions are generated, but contained. Tension at the most basic level has also been created in the area of technological policy, largely due to a growing realization in Germany, as in many other countries, that economic policy is becoming a function of international technological competition, rather than the other way around. But the German preference for allowing market forces to prevail, and for applying a strict competition policy regime to the same end, has been undergoing increasing strains - a theme that will be further explored at the end of this chapter.

Small Firms

For small and medium-sized firms, the government emphasis on firm-specific innovation support (despite the large number of firms) flowed from a conviction that small firms would not move quickly enough, if at all, in their application of microelectronics unless they were pushed. Since 1972, BMFT's small-firm project promotion rose from $6 million to $37 million in 1977. In 1975 the BMFT started a special electronics support program for small firms. Without saying that it wished to change the structure of industry, the BMFT nevertheless began to fund experiments that resulted in mergers among small firms.

After the institution of the 1975 program, the BMFT, acting through intermediate agencies, established working groups with members from various industry sectors to look for promising candidates in the manufacture of office equipment and machine tools. Eventually, it decided to "tackle" the watch and clock industry, primarily in the Black Forest area. Individual small firms received microelectronic grants, on condition that they form groups around particular projects and talk among themselves. The resulting mergers were considered a better outcome than the success of the technical projects themselves. While the watch industry still had problems, the clock industry began to prosper with its new technology and structure, and to expand its market share. "Here was an example of sensitive and intelligent guidance on the part of the government," observed an independent consultant. The agency, trying to animate the chosen sectors on behalf of the government, organized numerous meetings which were attended by hundreds of people. In the clock and watch industry, regular seminars became the order of the day.

It is accepted that, at least in the promotion of microelectronics, governments cannot sit back and expect small firms to respond automatically to government offers of help; whereas the large firms are much more aware of the threats of international competition. If this is the case in West Germany, the problem must be more acute in countries where small firms do not have as much of the world market share in highly specialized fields, as many small German firms have. Several small German machine tool manufacturers hold up to 60 or even 70 per cent of *world* market share in their line of business; one small German firm has almost a world monopoly on automatic gas analysis techniques using chemical processes, and the same applies to measuring technologies in the optical industry.

The perceived needs of small firms in West Germany have also been the catalyst for a belated recognition in the central ministries of the role that government assistance can play towards the *marketing* end of the innovation cycle. Once again, this new tendency has surfaced in the application of microelectronics. A new microelectronics scheme, in the works toward the end of 1981, illustrates the catalytic role of this development. The scheme would enable *all* firms, both large and small, to gain assistance with the *first* application of microelectronics technology in their processes and products. The maximum grant, based on R&D expenditures incurred inside or outside the firm, would be $300 000 over three years. The formula would allow a firm to add 80 per cent to expenditures for operational costs, such as working capital, in order to qualify for 40 per cent of the gross amount by way of a grant.

A willingness to give even large firms some assistance towards the application or commercialization of a product or process would run counter to one of the most strongly held positions taken by spokespersons for large firms; namely, that the state has no business becoming involved in anything approaching the marketing activities of firms - not even to intervene in the selection and production of outputs. Selectivity should be confined to fields of basic research. As one government official expressed it: "The government simply does not want to interfere in company policy."

Not surprisingly, therefore, even the new Berlin VDI Technology Centre for small and medium-sized enterprises does not help such firms with commercial problems. It concentrates on product and process innovation, particularly the latter in the case of microelectronics. The VDI realizes, though, that R&D in small firms cannot be separated from the rest of the innovation cycle, especially because the concern of the Centre is as much with the *survival* of firms as with their technology. Over its first three years of operation, the VDI had nearly 700 applications for help. With 40 employees and with the assistance of university experts, research centres and even industry, the Centre was supporting 50 projects per year. It also set up branches in other regions, in order to be closer to its clientele. In a way, the Centre is an arm of the BMFT, even though it is formally linked with the Society of German Engineers. With BMFT financing, the Centre was spending approximately $27 million per annum by 1981; $16 million on microelectronics. Because the VDI had to aim beyond mere technological advice - to "inform and motivate" firms - it must contend with a degree of opposition by interest groups, such as the professional consulting community that is still strongly biased against state intervention in the marketing and commercial policies and activities of firms.

Despite the very clear growing commitment to the diffusion of microelectronics throughout the vast infrastructure of small, often highly-specialized firms in West Germany, informed analysts would not have been able to claim that "a comparison with other countries shows the much bigger size of German support to the electronic industry in general and the semiconductor industry in particular,"[13] if there had not been so much interaction between the government and large firms and if the German policies had not been aimed at the entire filière microélectronique.* The government had already set a precedent of close involvement with large firms when it funded

*Semiconductors, computers, software and applications.

90 per cent of the cost of forcible merging of firms like Dornier with others in the aircraft industry. Subsidies of 80 to 100 per cent to large firms have not been unknown where national economic interests are at stake.

The Bargaining System

The West German administration appears to be quite flexible in its implementation of innovation support policies. "In principle, everything is negotiable," despite the fact that the ground rules for incentives are meticulously spelled out in the applicable manuals.[14] Unlike the French, the Germans do not rigidly adhere to the 50-50 rule. The flexibility of the German system lies in its ability to match carefully the costs and benefits and conditions attached to grants, in proportion to the percentage of money contributed by the government. Accordingly, in a bargaining situation, officials and firms are able to "play the variations" up and down the scale, ranging from 25 per cent subsidies to 75 per cent or more. Such a situation for negotiation exists because, like the French, the Germans have a two-stage bargaining process. But in this case at the first stage the competing companies, the officials and experts may actually meet in one room to discuss worthwhile projects; whereas in France, the dossier and the corporate shopping list is strictly a matter between the individual company and the bureaucracy.

In Germany, support programs are designed in consultation with the companies and outside specialists. Government has to "ascertain what amounts of money can reasonably be absorbed by the industry," asserted a responsible official in a central ministry. Program coordination takes place at the design stage. When the programs are off and running, the government tries to identify technology gaps. Interested and qualified companies are invited to a meeting with an advisory panel of seven or eight experts. An "open" discussion ensues among the competitors about the range of possible research projects on the planning horizon. Typically, a company will make a presentation of no more than 10 or 15 minutes followed by a discussion of about the same length. Questions are asked and "intentions are declared." Companies may also adjourn to meet bilaterally outside. The time limits on the discussion do not permit the disclosure of commercial secrets, and in any case, a company can ask to meet with the officials and outside experts separately. The latter group convenes separately in any event, and if they have questions, they may call in firms to clarify points. In most cases, firms receive enough feedback to be able to assess the probability of accepting a concrete proposal in the next, more specific, stage of the proceedings.

The process helps discourage unproductive competitive R&D by firms, even if they had not intended to apply for a government grant.

But because of competition, even the largest firms have to bid honestly; if they do not, smaller, more specialized firms may snatch the promising projects, especially if a large firm does not appear enthusiastic about the possibility of a 50 per cent grant with its attendant set of obligations and freedoms.*

The two-stage process helps maintain a certain necessary distance between government and company. Even in those rare cases where the government owns or controls an enterprise, as in transportation, energy and other basic industries as well as some relics of wartime defence industries, only the Finance Ministry is represented on the boards of directors of the affected companies. (A ministry like the BMFT cannot possibly be represented because it is a source of funds and may, therefore, have a conflict of interest).

The two-stage process also allows the government to confine attendance at the first stage to "reputable" firms, which, even though foreign-owned, have been "adopted" as good corporate citizens. Good corporate citizenship is fairly narrowly construed. It seems that if a foreign company maintains a standard of ethics, which, for example, ensures that defence contracts are undertaken with due regard to local exigencies of security, or if the company enjoys some form of world product mandate in some speciality, and, most important, if it uses its subsidized expertise for manufacturing primarily inside West Germany, then such a company may experience no difficulty in securing an entry into the bargaining process.

Terms and Conditions

Whether foreign or German, all companies sign the same forms of contract. The government makes no effort to insinuate itself into any other aspects of the company's business, behaviour or performance. Only the amount of *money* awarded is negotiable, not any other types of offset activities. The government brings no public or social conditions, other than those in the rule book, into the bargaining process. By concentrating on selected projects, the system allows those projects to be managed as discrete and independent entities; thus limiting the prospects of government access to information about other activities of the firm. No equivalent of the French dossier exists.

As a practical starting point for negotiations, generally the appropriate level of support is determined by the distance of a project from the point of commercial marketing. The firm's need for money and its willingness to shoulder the prescribed obligations auto-

*Bargaining is considerably expedited if a given level of grant is also a proxy for a predetermined set of contractual constraints. For this reason, those attendant conditions, at any given level of support, are rarely open to separate bargaining and relaxation.

matically attached to the contemplated level of funding, plus a calculation about the hands of the other players in the bidding modifies this general rule.

The application for specific project money is very detailed, and plans are in hand to simplify the documentation for small and medium-sized firms. However, the thoroughness of the submission has tended to help large firms in particular to sharpen their own internal assessment capabilities and to impose management controls upon workers that might otherwise be difficult to justify.

The initial application for project approval is still less detailed, however, than the subsequent applications for payments with respect to work done. The initial costing estimates and planned work programs extend two years into the future. The government has extensive inspection powers and the firm must formally acknowledge any other subsequent useful information conveyed by the government. Substantial subcontracts have to be approved by the government, which, in general, must be awarded through a competitive tender system. Guidelines outline various categories of preferred suppliers, such as small businesses and disadvantaged persons or areas. Foreign subcontracts cannot replace competitive local sources. The applicant may have to use designated installations and equipment. Interim progress reports are required bimonthly. Unproductive or nonexploitable results must be disclosed, as well as resulting inventions, patent applications and patent rights, including those of subcontractors. And unless the government decides to the contrary, information about project results must be made known to interested bodies within the country within six months of completion to avoid duplication and to share experience.

The government has a nonexclusive right to use the results of subsidized R&D in certain ways, but only after hearing the views of the grantee. Firms must accommodate third party access to the technology for use within the country, on certain terms and conditions. In special circumstances, and possibly against a special payment, the grantee firm may gain exclusive rights of exploitation. In the event of successful commercial use, and within the first eight years, firms must repay 40 per cent of the grant out of all earnings beyond certain levels and notify government within a month of cooperative agreements with other firms and licences. If people outside the country are involved, prior approval is required. If firms make substantial use of their subsidized technology abroad, without approval and in conditions under which they are or become foreign-controlled, then the government may recall the grant and invoke the right to gain access to information about manufacturing methods. After the grantee has been heard, grants may be cancelled without any reasons being given. It is interesting to note that grantees are obliged, within four years of project completion, to notify the government of any important innovations or improvements possibly connected with the project work. Firms must also negotiate the exploitation of any such additional developments, if a failure to do so would seriously impair other R&D work promoted by the government.

Special Situations

The above-mentioned are the types of conditions that might or would apply to an average R&D contract. However, the system is flexible because some of the conditions apply to different levels of financial support. The foregoing stipulations would normally apply to any grant amounting to between 50 and 75 per cent of project costs; variations occur with grants below 50 per cent or above 75 per cent. Important instances of such variations are noted below.

In practice, most projects receive 50 per cent subsidies. One example of the flexibility of an otherwise apparently rigid set of rules is a case in which a large firm undertook a software development project. The firm reached a compromise with the government because the work was near the marketable stage and under normal conditions the grant would have been repayable. But it was difficult to decide how marketable the know-how was, and the parties agreed to a 25 per cent grant with no repayment obligations. The real snag was that if grants are repaid, the government does not acquire user rights in the technology; and if the grant is not repaid, those rights must be shared with the government. So to enable the company to hold on to the technology exclusively, even though the product was nearly marketable, the elegant solution was to give the firm a lower than normal grant.

Quite clearly, many companies refuse government subsidies to avoid the user-right sharing conditions. The fact that the company must also report on any unpatentable know-how derived from a project, and that the government also has a right to such unpatented know-how once it is entitled to user rights, accounts further for corporate sensitivity about user conditions.*

Government recognition of these corporate interests is also reflected by a very practical rule, whereby the government is only entitled to the "older know-how" (developed by the firm before it received a grant for further work) that has helped support the new subsidized know-how in cases when a grant exceeds 70 per cent. Corporate interests are further protected because the government's entitlement to old know-how is not enjoyed by other firms where such firms become the recipients of obligatory transfers of newly-

*The government experts who have rights of inspection while work is in progress are reputed to be astute.

developed know-how. The practical consequences are worth noting, because the rule effectively inhibits forced transfers of subsidized technology.

We will now take a closer look at differential conditions applied to large (of more than 75 per cent of project cost) and small grants (of less than 50 per cent). In the former case, the government retains special rights over materials and equipment acquired by a company for use in connection with a project; in effect, such rights belong to the government. The government's right to approve *subcontracts* is triggered at a relatively low level for large-grant recipients. But for small grant recipients, the company is relatively free to subcontract because the trigger level is twice as high as in the former case. Government can compel medium and large-grant recipients to use designated facilities for the execution of R&D contracts; whereas small grant recipients are exempt from this stipulation. While all recipients must surrender information about R&D results, small recipients are excused from more detailed disclosures of all relevant documents, such as parts lists, circuit diagrams, computer programs and even calculations, as well as background information on the state of the art and related commercial practices. Large grant recipients carry heavy obligations in the area of precautionary searching of conflicting research activities and patents and third party rights. They also have relatively greater responsibilities to cooperate with any third party nominated by the government to utilize R&D results. Note that careful distinctions are made when it comes to giving licences to third parties. Only small grants are available for projects close to the marketing stage. When a small grant project is suspended, the government's absolute right to do so is tempered by the obligation to weigh the company's financial interests, if the company was not to blame.

The foregoing conditions illustrate further the extraordinary effort made to achieve a balance between the degree of financial exposure of the parties (in percentage terms) and the obligations imposed upon a recipient company. That everything is not "beer and skittles" can be gleaned from the fact that grants are rarely renegotiable and cost overruns can reduce the nominal level of subsidy to considerably lower real levels. However, unlike the French experience, government payments are prompt. The government is not too sympathetic to complaints that repayment obligations based on turnover levels may come into play long before a company may have covered its own R&D costs.

Foreign and Large Firms

With some special exceptions, foreign companies do not have any substantial access to direct government incentives for R&D, partly, one assumes, because they may not be interested in the ground rules. Recently, however, an American microelectronics subsidiary had 28 of its projects supported in a single year. Another foreign subsidiary's working relationship with the government is so well-established that its subsidized projects may involve "large amounts of money that are now simply moved on the basis of telephone conversations."[15] One foreign firm actually succeeded in increasing its subsidies for microelectronic projects by a factor of 10 within only a few years.

Cooperation between government and large firms appears to rest on a mutuality of interests where the firms are prepared to make a commitment to local expectations, particularly local production, but where the government places strict limits on any ambitions to exploit public incentives unduly. Evidence of this attitude is the acknowledged consensus that firms may in practice appropriate the results of government-subsidized R&D for their own use and carve out discrete projects that keep the government's fingers out of other corners of the company's affairs; the ability of firms and authorities to choose from a sliding scale of contractual obligations in direct proportion to the level of funding, and the willingness to, in effect, put projects up for competitive bidding through a subtle process of open meetings. However, this relationship is tempered by a pervasive feeling of guilt about the propriety of selective intervention at the firm level in an economy that has thrived on the maintenance of competition and the wielding of macroeconomic and horizontal policy instruments. The resulting built-in tension will probably help to preserve the diversity and, for that matter, ambiguity of the West German innovation support system.

Overview and Prospect

At the beginning of the 1980s, the German commitment to new technology received a new impetus. The former Electronic Components Program became the Microelectronics Program in 1981, with additional allocations of money to lift planned expenditures to $125 million in 1982. Support was made available for all stages of project development up to prototype. In November 1981, Baden-Württemberg announced the creation of an Advisory Service for Microelectronics at the University of Karlsruhe. The Service would work closely with the AEG Development Centre for Integrated Circuits in Ulm to develop custom-designed circuits for the benefit of interested firms. The Service would also help with cost analyses, the search for suitable business partners, and the design and monitoring of technical development projects. As well, it would provide market information, and even undertake systems analysis of potential applications.

It is clear that West German planners leave no base untouched, and the design of the Microelectronics Program is no exception. Process technology support covers structure definition, layer production, testing and control and submicron research. Subsidies for design and system technology are equally varied and detailed, and the same applies to the development of peripherals (sensors, actuators and image technology). Support of applications and of socioeconomic research is additional to the funding of materials and basic research. A program to underwrite research in communication technology, covered by a work plan for the years 1978 to 1982, concentrated on transmission, input/output, reproduction of text and images and a variety of applications. And, at the beginning of 1982, the BMFT announced a Special Program for Microelectronic Applications, which would run for three years, to finance the development of marketable products incorporating microelectronics; $160 million was earmarked for this purpose, with no individual grant to exceed $426 000.

Giovanni Dosi has applied various indicators to the national semiconductor industries of Europe, and concluded that "[West] Germany emerges as the best placed."[16] Most noteworthy have been the sheer comprehensiveness of German support, and "the timing and size of industrial policies."[17] A series of data processing programs has existed since 1967, and a separate fund for semiconductor components since 1974. "A comparison with other countries shows the much bigger size of German support to the electronic industry in general and the semiconductor industry in particular."[18]

New strains in the system are evident, however. They are markedly concentrated around the issues of aid to small firms versus large firms and competition policy. Many commentators claim that German competition policy has been even tougher than the American antitrust regime. For example, a company with a turnover of more than $1 billion cannot buy out companies over a certain size, if they are in a market characterized by small and medium-sized enterprises. The objective is to protect the structure of the market. There have been exceptions, where the government felt obliged to participate in, and to promote, very large ventures, notably in aerospace (the Airbus) and atomic energy. But generally government is reluctant to help basic industries, such as coal, which are already highly concentrated.

Not surprisingly, therefore, the problems arising within central federal ministries are very much a function of differentiating between large and small firms. The difficulties are most acute in the area of government support in such internationally competitive fields as microelectronics, where not even the largest German firms have the capability to compete with American and Japanese enterprises. This is clearly the case with the development of very large integrated circuits or automated design systems, so that even Germany is forced to be selective in its efforts to keep up in microelectronics. There is still an uncomfortable dependency on the US in such key areas as the analysis of circuits, at a time when the big foreign multinational enterprises are "closing up," sharing less technology and doing more custom-designed work for strictly internal consumption.

An added factor is the growing capital intensity of some parts of the microelectronics industry, for example, in automated design, that makes the cost of equipment prohibitive for smaller firms. Under such circumstances, the need for government to try to persuade even some of the largest firms to cooperate in joint ventures can be no less painful than decisions taken years ago to start pouring project support into large firms to enable them to catch up with American and Japanese expertise.

The "party line" has persistently maintained that horizontal and macroeconomic measures are preferred methods of promoting investment and innovation. But the dilemmas created by the Japanese onslaught in high technology areas are almost amusingly evident in recent talk about a need for "indirect specific measures." Says an onlooker: "Such a thing could not really exist, and no one really understands what 'indirect specific' means." It means, at the very least, that government and the private sector perceive a growing need for targeting government assistance to specific technologies and firms, in parallel with a realization that economies of scale are unavoidable in some fields of high technology. A particularly acute problem is the future of the German machine tool industry. Although it has an excellent mechanical engineering capability, it is nevertheless vulnerable to the Japanese electronic incursion.

In prospect, the question remains whether the relationship with large firms, a vital component in the international competitive struggle in the field of microelectronics, can be sufficiently "strategic" and effective if it rests on a purely project-oriented support base. How effective can government departments be if they are exposed to a form of cognitive dissonance with respect to the needs of an industry such as microelectronics, which still requires a heavily supply-oriented approach involving the pushing of technologies and firms? One is reminded of the eventually intolerable contradictions to which a free enterpriser like Sir Keith Joseph* was subjected in the UK.

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*Sir Keith was compelled by circumstances to live with a degree of state intervention that went totally against his grain.

In a country like West Germany, where trade union interests are strong, but inevitably concentrated on the immediate and the shorter-term exigencies of job creation, how easy will it be to design and implement long-term policies and programs where there may well be a requirement for highly selective leapfrogging over American and Japanese competitors? Even from a purely technical point of view, the need for supply-oriented policies is accentuated by a realization of how small a percentage of the world electronics market will be taken by integrated circuits by the mid-1980s, and by a realization of how large the *leverage* of microelectronics will be on the whole field of production and applied product markets around the world. At a time when even Germany's largest microelectronics firm is experiencing technical and marketing problems, despite its healthy cash position, the need for serious strategic planning between governments and large players in the international field has become more acute.

VI. Sweden

National Commitment

General Industrial Support

For more than a decade, Swedish industrial policy has concentrated on regional development, assistance for small businesses and support for increasingly vulnerable traditional large industries. Much assistance went into steadily-declining industries. Even as late as the 1970s (1970-77), government funds allocated to industry reflected a stodginess, shown by the fact that during those years fully 73 per cent of total funding went into shipbuilding, steel, textiles and clothing, and forest products. Of the remaining funds, fully 10 per cent flowed into the aerospace sector and 8 per cent into automobiles and mechanical engineering.

State involvement in the traditional heavy sectors of industry was also expressed by the role of the state holding company, *Statsforetag*, which controlled more than 30 industrial and trading enterprises, not counting other so-called "special program operations." In 1980, those enterprises and operations employed 46 000 people. They include Sweden's largest mining company, Scandinavia's largest textile and clothing company and Sweden's largest producer of sawn timber products and derivatives. *Statsforetag*'s consolidated balance sheet in 1980 disclosed total assets of $5650 million.

Because of the setbacks in the traditional industries in the 1970s, industrial policy became markedly defensive, with heavy government involvement in job subsidization. In the late 1970s, subsidized on-the-job training programs accommodated as many as 140 000 people. One informed estimate of government expenditures to bail out lagging industries, between 1975 to 1980, mentions an amount of no less than $6.8 billion (1975-80).

Under the regional development scheme, subsidies went to business activity in six development areas covering 77 per cent of the country and 30 per cent of the population. The scheme supports up to 70 per cent of buildings and equipment with interest-free state loans, of which 50 per cent may be written off after three years and the balance after seven years. Additional loans for up to 20 years are available for current assets, product development and marketing expenses; interest and redemption payments may be foregone for the first five years. The scheme pays for employment grants for up to seven years, up to a total of $31 000 (1981) per job and offers special development grants for unusual projects and transport subsidies of up to 35 per cent of freight costs.

Other significant industrial support measures include the Norrland Fund and the Swedish Investment Bank, which was started in 1967 (with a share capital of $293 million and a lending capacity of eight times that amount) to finance large, comparatively risky projects for the reconstruction and streamlining of Swedish industry.

Fully aware that Sweden performs less than 1 per cent of world R&D, the government places much emphasis on technology transfer; the state holding company, *Statsforetag*, has even bought out small bio-engineering firms in the U.S. The Department of Industry is the secretariat for a technology imports committee with government and industry representation, which helps firms find new technology, advises them on licensing, and even funds exploratory trips abroad.

As Sweden is a trading nation, government support for export activities is a substantial factor in industrial subsidization in general. The Swedish Export Council (SE) provides a wide range of services, including the Trade Commissioners' Service. The Council is funded by the Department of Commerce; its annual budget is around $38 million. It would be remiss not to mention in passing that government procurement plays a decisive role in the support of the aerospace industry and, of course, in the general area of defence equipment.

Research and Development

Sweden has no central R&D budget, but the government pours vast amounts of public money into R&D through various departments. In 1979-80, for example, the Ministry of Industry accounted for only 10 per cent of national R&D grant expenditures ($281 million); whereas the Department of Education spent $440 million, the Department of Defence $271 million, the Departments of Agriculture and Social Affairs $119 million and $91 million, respectively. Over the same period, tax incentives for R&D performed in industry cost the government an estimated $48 million per year (net). Extra tax deductions were introduced in 1973. Some commentators feel that tax incentives have had no noticeable effect on R&D, "except perhaps statistical," thanks to changes in corporate accounting practices designed to reap the benefits of the new formula.[1] Fully half of the national industrial R&D effort is financed by businesses.

The government has created several institutions to promote technological innovation. The Swedish National Development Company (SU), a subsidiary of *Statsforetag*, not only undertakes central R&D for its parent company, but also starts up special projects potentially exploitable by the *Statsforetag* group; in addition, it assists private inventors. This is not a major undertaking - annual operating expenditures are at the $3 million level. The Industrial Development Fund was set up in 1979 as a government foundation, managed by a relatively independent board of directors, and given an initial capital infusion of $82 million. In 1981, the government voted the Fund an additional $107 million for three years, to invest in high risk projects. Its annual lending capacity is $48 million per annum.

The best known organization is the Swedish Board for Technical Development (STU), which has a very wide range of activities covering almost the entire spectrum of applied research. It awards research grants to industries, institutes and individuals, emphasizes the promotion of cooperative industrial research, and complements industry-focussed research by promoting specific generic technologies applicable to many industries. Annual STU expenditures are approximately $143 million.

Electronics

Despite its heavy reliance on resource-based industries, Sweden has, over the past two decades, developed a significant technological capability in electronics, which, when combined with Swedish expertise in the production of machinery and sophisticated defence equipment, will perhaps be a valuable base for future exploitation of applications. The computer and telecommunications industry already contains a number of well-established names, with *L.M. Ericsson* standing out. Industrial activity spans the field of computer hardware, software and applications, systems services and telecommunications in an environment of great public consciousness of the information revolution and an equally strong awareness of Swedish vulnerability to international competition. In 1974, Sweden exported 84 per cent of its computer production; imports were substantial as well.

Swedish awareness of the urgency of the microelectronics revolution is mirrored by the recent, but still relatively modest, expenditure budgets of the STU. In 1978-79, STU allocated $9 million (1978-79) to information processing and electronic components technology - a level more or less maintained in 1979-80. It was not readily apparent to what extent other allocations such as for example, production, processing and even energy technology also went to electronics, not to mention the electronic R&D component of aerospace, telecommunications, defence and other budgets.

In its assessment *Technology for the Future: Perspectives 1979*, STU remarked on the almost inexhaustible list of applications that would flow from developments in automation, information processing, measurement and control systems, if they were exploited.[2] In particular, STU emphasized that the *integration* of the new technologies would generate for new products, processes and systems, and that the new technology posed grave implications for the engineering industry. Computer applications would have to be inexpensive, for Sweden to compete internationally. With its repeated stress on low-cost breakthroughs in process control, communications and so forth, the report clearly had microelectronics in mind, though it did not specifically mention the field. The need for Swedish industry to absorb and exploit new developments in electronics permeated the entire report.

Practice and Implementation

The Investment Climate

"It is wrong to regard Sweden as a centralist socialist state. The country is not centralized at all. There is a large variety of independent authorities ... there is considerable diffusion of decision making. And there are many regional organizations which make purely regional decisions."[3] A good example of this state of affairs occurred in the uranium mining industry where vital decisions were entirely in the hands of a regional authority, whose final say rested on the fact that the mines were located within its area of jurisdiction. In the steel industry, Sweden and the EEC made an agreement but the Swedish government does not have the power to impose the agreement on Swedish firms. So decentralized and dispersed is the system (remarkable for such a small country) that the staffs of central ministries in Stockholm are almost ridiculously small. Not unexpectedly, consultation takes up an inordinate slice of administrative time and the preparation and production of voluminous analytical and advisory reports are almost at the point of being an industry of their own.

In the field of Swedish industrial and innovation policy, the Boston Consulting Group produced a comprehensive report in 1978 which led to the formation of a Special Industrial Committee, whose report was published a year later.[4] Then the prestigious Royal Academy of Engineering Sciences (IVA) weighed in with a blockbuster of its own which cost $1.2 million (1979), not to mention a Special Parliamentary Commission on Electronics, which, working in parallel with STU, produced the comprehensive *Perspektiv 1979*.

Apparently, the most effective locus of industrial strategy formulation is not in the Department of Industry but in bodies such as STU, whose planning staff is quite large compared to that of the department. Being an employer of around 270 people, STU is thought to have the necessary personnel and competence to carry out the promotion of technological innovation. However, we have seen previously what a small proportion of national R&D is provided, steered or affected by these two agencies.

Much innovation support goes to education and skill training; expenditures to protect jobs accounted for the bulk of the $6.8 billion spent on steel and shipyards from 1975 to 1980. A data reference group recommended that 28 new professors be appointed in data processing education and that every university have a computer-oriented professional engineering capability to teach microelectronics at each technical college in all fields, such as chemistry, and machinery and civil engineering. Almost the entire system of tax-based R&D support is predicated upon job creation and protection.

Over and above the usual straight deduction of R&D expenses and depreciation of fixed capital investment, an additional tax incentive relates to personnel costs; "R&D is not performed by machines but by people."[5] A job counts as a tax deduction if the incumbent spends 50 per cent of his or her time on R&D (25 per cent in small firms). From 1982, the basic deduction will effectively be 7.5 per cent and the deduction for incremental R&D 45 per cent. An innovation bonus was also made available in 1982, entirely related to employment in R&D.

The lack of any national coordination of R&D and industrial policy highlights the fact that Swedish socialism has been primarily associated with social welfare and employment protection. As far as planning is concerned, corporatism exists only at the "specific" level. Trade unions participate in planning only in conjunction with the activities of official organizations and commissions. A policy of active codetermination makes consultation with workers obligatory before a company makes a key decision; the final decision, however, is the prerogative of the employer.

Not only are purely private organizations such as the Swedish Employers' Confederation (SAF), the IVA and the Federation of Swedish Industries (SI) completely free of trade union participation, but even the partly government-financed SE has no trade union representation. Its guiding board comprises four government and four industry representatives; it performs a very important function of trade promotion and representation, with an annual budget of $38 million. The SE is totally reactive; it merely responds to the companies' declared needs. Government ownership of companies has also tended to be related to employment problems rather than "strategic" considerations; and even the affairs of publicly-owned companies are in the hands of quite independent boards of directors.

If Sweden has little experience of government telling big firms what to do,[6] it has an equally indifferent record of purposeful government procurement policy, outside of the aerospace sector and the remarkably self-sufficient area of defence. Defence procurement, however, has not been as fruitful in supporting basic R&D as in the purchase of tightly specified products. One cannot, therefore, claim any notable "strategic" use of procurement policy. Individual companies such as ASEA, which, on principle, accept no government subsidies, benefit tremendously from straight purchases by public agencies of nuclear power equipment and railway stock; but even ASEA's remarkable success in robotics has been entirely due to its own efforts.

Contrary to impressions, Sweden's national champion, L.M. Ericsson, does not rest its international marketing success on a strong domestic sales base. On world markets, almost one half of Ericsson's sales are in telephone switching systems, with less than 1 per cent of its switching output sold in Sweden. The Swedish telecommunications system is government-controlled and operates its own factories.

Much of the governmental intervention in procurement has been concentrated on helping local authorities or government agencies "to make more intelligent decisions."[7] STU hires consultants and carries extra procurement costs, especially in the specification phase of procurement - another example of educational rather than direct intervention.

Precisely because of a sharp decline in public procurement and the growing share of corporate budgets consumed by manpower costs, the government introduced tax rebates for R&D in 1973. But the government could not, or would not, meet even the funding requirements of the automobile branch of Volvo, to help that company remain technologically competitive.

The fragmentation of Swedish policy formulation and implementation is part and parcel of an organizational structure and processes neither designed for, nor lending themselves to, national strategic planning and intervention for investment and innovation. But while the public sector is so diffused, the large bulk of important R&D is being performed by a small number of large firms in a highly-concentrated industrial sector; Ericsson, ASEA, Volvo and Saab perform approximately 50 per cent of industrial R&D in Sweden. Few new companies have entered Swedish industry.

How then, in the promotion of high technology, do public or quasi-public agencies that deal with companies succeed in maintaining a traditional arm's length relationship where public support takes place at the enterprise level? How are the direct support measures designed, and what are the operating conditions?

Terms and Conditions

When grants or loans are awarded by an important agency like STU, they are confined to discrete projects. Negotiations take place consistently within the framework of more or less standard sets of contracts. Bargaining does not extend to aspects of corporate performance unrelated to the research project's technical and financial features, except that recipients of funding may be required to cooperate with and make results available to other firms; this latter stipulation is based on the argument that firms other than the recipient may be better qualified to apply the research results. Considering the claim that STU is in fact the "most strategic" intervening agency in the area of industrial innovation, the narrow scope of a STU contract is indeed surprising.

Conditions vary among large firms (employers of more than 500 people), medium-sized firms (between 20 and 500 employees) and small firms (fewer than 20 employees). Large and medium-sized firms may not receive loans exceeding 50 per cent of project costs, except where firms will not benefit from the project; in such cases assistance may reach 100 per cent and the recipient must agree to publish the results. Large firms only qualify for loans for projects with a *high* level of technical risk or *ordinary* technical risk where expected economic gains are associated with social, medical or other public interest criteria. Medium-sized firms qualify for loans for projects with technical risks and that can be expected to produce economic benefits. The same criterion applies to small-firm loans. However, small firms may also benefit if they have no financial resources, and, if they cannot exploit the results, a reasonable prospect must exist that the results can be protected by a patent.

All firms may receive advance payments of up to 25 per cent of project costs. Progress reports must be brief. The final report must contain a technical summary not exceeding 200 words (plus an analysis of costs and cost allocations), and a statement of opinion on the prospects for commercial exploitation and further development. Where loans are repayable, annual reports on the exploitation of the results have to be submitted until final repayment.

Repayment conditions vary among categories of firms. Large firms must repay the entire loan over a five-year period if the desired technical results are achieved and opportunities exist to exploit them. If the firm does not achieve the expected technical results, but there are prospects of income yield from the subsidized work, it must apply one-half of licensing or related net income to repayments, plus 7 per cent of manufacturing sales. Medium and small firms that *have* achieved technical results are bound to the same repayment conditions. For loans of more than 50 per cent having no prospect of economic returns, the recipient is obliged to place the results of a project at the disposal of the government granting agency, where others need only acknowledge government support if they publish the results. However, if the government cancels a repayment obligation, the recipient must agree to the publication of the project results; except under special circumstances such cancellation can only take place after ten years. Compared with government-user conditions in France and Germany, these obligations are remarkably generous, considering how firms attach such importance to exploitation and publication stipulations.

Once repayments begin, Swedish firms pay interest at a rate perhaps 3 or 4 per cent above market rates, dating from the time of disbursement. It seems that recipient firms may not transfer their rights to technical results to other parties without the granting agency's approval. An obligation to exploit results within the country is presumably the governing concern, as well as the possibility of technology being transferred to foreign-owned companies. There is a distinct impression that foreign-owned companies would only rarely qualify for support. Certainly, any proposal to exploit subsidized technology outside Sweden requires prior approval. Considering the heavy dependence of large firms on research, it is significant that they have to repay loans as soon as they achieve technical results, regardless of whether commercial success by way of sales follows.

As we have noted, in France firms must enter into onerous 50-50 contracts; whereas in the UK, firms tend to avoid 50-50 subsidies, preferring 25 per cent grants because the former are loaded with unwelcome conditions. In Sweden, firms do not mind 50 per cent grants "because the obligations imposed upon them are not heavy."[8] And even though the government reserves the right to use subsidized technology, in practice even a 50 per cent recipient firm remains the effective owner of project results.

Large Firms

The government also offers generous conditions when a large firm contracts to perform R&D for a public utility. An outstanding example of such a fruitful association is where a private firm undertakes most of the R&D required by the public firm, with each paying an agreed share of the costs. A joint board controls the projects. The public firm, as the user of the results, provides the private firm with a valuable opportunity to conduct early domestic market tests of new products, which helps in various ways to support and promote the private firm's subsequent international marketing activities. Either of the two companies can take over a new product for further development. While each company can use the technology and know-how for its own purposes, the private firm has the sole right to sell the new technology to third parties. In this manner, the public sector helps support the private in a fiercely competitive international market. The best known example of this type of arrangement is the 50-50 joint venture between L.M. Ericsson and Televerket (the state telephone company), a partnership that is the basis for the remarkable international success of the AXE telephone exchange system.

An interesting feature of the relationship between large firms and government granting agencies is the fact that universities are often involved, on the usual project basis; this gives universities an opportunity to contribute to technical advancement. One of the most frequent corporate recipients of government project funds rarely employs such funds without involving a university or technical institution, although the corporate partner remains the project leader and receives development rights. Universities are interested in involvement with corporations because, under Swedish law, inventors at universities own the results of their research. The government-owned Swedish National Development Company (SUAB)* has worked through a university group on projects in pattern recognition systems and biotechnology.

At present, large firms are finding it more and more difficult to finance large high-risk and long-term projects. Some of the reasons are low profit levels, climbing interest rates (thereby weighting short-term projects more heavily), a decline in public procurement in such important sectors as nuclear technology and even defence, and social welfare pressures causing the diversion of resources to employment support from material procurement, replacement and maintenance. New R&D tax incentives have not had much of an impact on large firms. Even in the automobile industry, imported components are making heavy inroads into domestic production and supply.

Industrial Development Fund

The Swedish government has increasingly realized the need for a more far-sighted and intelligent relationship with large firms. In 1979, the government established an Industrial Development Fund for large firms' high-risk short, medium and long-term projects, allocating some $82 million (1979) for two years, followed by a further infusion of $107 million (1981) for another three years. A remarkably relaxed and generous attitude is said to characterize the policies of the board of directors of the Fund, which is small, and includes a trade union representative. Loans not exceeding $12 million are given out on a project conditional basis only, for if a project fails the money is lost. The Fund takes risks on projects, not companies, and charges interest at market rates; thereby ensuring a healthy income for itself.

*The company even brings in proposals from abroad and helps small firms with the important initial step of putting together an appropriate search profile for new technology.

Repayment is tied to success of a project, but the Fund's board has the sole right to decide on a project's success or failure. Generally, failure is deemed as the absence of commercial value to the firm (the firm owns the proprietary rights to the results). The Fund may require that the firm transfer the results to another company. The board's prerogative to decide on success or failure rests on the sensible acceptance that good research results may often be quite different from those originally desired or planned.

In 1981 the Fund began to experiment with a new type of "loan," amounting to 50 per cent of project costs. The loan is not repayable, but it earns royalty income, which does not cease even if payments exceed the original loan. Companies do not have to enter the loan among the liabilities on their balance sheets but can, in fact, treat it as income. Again the funding is not firm-related but aimed at a specific project with a specific product in mind; thereby concentrating as much on the *marketing* end of the innovation cycle as the front end. In some cases, the supported project may not rest on any new invention at all. Well-defined commercial projects, even of a long-term character, are the objective. Among recent projects is a large microelectronic venture with a private company. The project is ambitious, considering the competition in the field from the Americans and the Japanese.

More conservative institutions might not be impressed by the Fund's apparent willingness to help individuals *inside* firms to convince their own management of the merits of exploiting a new idea. One cannot, however, help but expect a favourable reaction from the business community once it realizes that the Fund is prepared to take a calculated risk on the local exploitation of project results in Sweden. The extent of this local exploitation requires a judgement to be made, and is, therefore, to a large extent a matter of informed trust. The board realizes that new technology is a valuable playing card in the hands of a multinational company. To the contrary, the board may well insist that a Swedish firm take on a capable foreign partner as a condition of the loan. The strong *foreign* expansion of Swedish firms has been a recognized trend for a considerable time,[9] to mention only the example of the Anaconda-Ericsson partnership with Atlantic Richfield in the American office equipment market.

Overview and Prospect

The seriousness of the Swedish commitment to promoting the new technologies can be judged from the work of the Commission on Computers and Electronics.* The Commission's report not only covers R&D, recommending new R&D institutes costing $50 million over five years, but also a wide range of activity including information programs, software loans, and training schemes that, *inter alia*, make provision for putting 65 000 union representatives through instruction courses. Much emphasis is placed on the diffusion of advanced automation.† These programs will cost $97 million over three years. The Commission's background studies and visits concerning industrial and R&D policies for computers and electronics have covered the US, UK, West Germany, Japan and France.

Sweden's concerns about its relative weakness in automated production equipment make sobering reading for any country still lacking a comparable engineering infrastructure. After all, ASEA has quadrupled its robot division personnel in a bid to solidify its number three position in the American market, and, after its acquisition of the robot division of the Swedish company Electrolux, it appeared well-placed to challenge even the US giants. ASEA had already successfully invaded the West German robot market, with sales to Daimler-Benz and BMW. In April 1982, ASEA entered the Japanese market for industrial robots. Also, electronics firms like L.M. Ericsson, as mentioned previously, are outstanding in the telecommunications industry; their industrial activity already spans the fields of computer hardware, software and applications and systems services. Ericsson also has a well-developed machinery and engineering capability, ready to adjust to the onslaught of microelectronic applications. In 1979, Swedish engineering exports reached $13.7 billion, machinery sales $7.1 billion, and the electrical and instrument industries alone, with sales exceeding $5.5 billion, employed nearly 90 000 people. Yet, despite these industrial advantages, the Swedish industrial economy has been, so to speak, running scared in the face of emerging technological competition.

In Sweden, responsible public authorities have been taking cautious steps towards a more strategic and planned approach to future industrial and technological development, without wishing to disturb the traditional arm's length and diffused relationship between the state and the private business sector. Like the West Germans, the Swedes are aware of the impossibility of taking short cuts in the advancement of the new technologies. They recognize that a lack of

*The Commission, which had been appointed by the government in July 1978, submitted three studies to the Minister of Industry in April and July 1981.

†In 1981, STU earmarked $62 million over a five-year period for R&D in engineering industries, of which $3 million will go into computer-aided design and manufacturing, and additional amounts into adaptive control of machine tools and industrial robots. Separate agreements with industry associations will cover five-year research programs costing $22 million.

skilled labour is a basic constraint, requiring educational intervention, and they have defined broad technological priorities, emphasizing information technology, electronics, biotechnology, materials science, clinical technology and computer-aided design and manufacturing. The main industrial innovation funding agency, STU, has begun to move towards strategic planning, from mere reaction to company-initiated project proposals.

Moreover, the government has begun to realize that past innovation policy neglected the different stages of the innovation cycles and has introduced new development schemes for specific new technologies, such as microelectronics. The time horizon for project planning has shifted to five and even eight years, but again the impetus has been a function of the skills, vision and enthusiasm of key individuals in the responsible organizations, rather than of structures and committees.

Mention of the critical role of individuals in key positions, and of their qualifications and competence, underlines a growing awareness that the *implementation* and delivery of government programs is the Achilles heel of successful intervention. This theme becomes almost a refrain: "We think we know what is needed, but the main problem is how to implement it." The age old ploy of departmental and agency reorganization as a response to failure is simply not working.

VII. The Netherlands

National Commitment

General Industrial Support

In its support of industrial investment, the Netherlands, like the US and West Germany, has been classified as a country "which relies on every kind of instrument, especially (investment) climate measures."[1] In this respect, the Netherlands differs from countries, such as France, where specific measures (direct intervention) predominate. The Netherlands' pluri-instrumental approach reflects a recent tradition of economic liberalism, intellectual liberty and tolerance, as well as a dependence on the free flow of international trade and the concomitant openness of the economy. It has always been in the Dutch interest to support multilateral agreements aimed at minimizing national trade and investment barriers, including non-tariff barriers such as discriminatory investment incentives and disincentives. Hence, the Dutch prefer to stimulate local entrepreneurial investment through tax-based incentives, whose availability to individual enterprises has been rather more general than discretionary. "Subsidy and stimulation have been used to arouse general interest in action, rather than to display power in a *dirigiste* manner."[2] Even sectoral policies have been regarded as temporary, given the Dutch preference for macroeconomic management.*

The Dutch have emphasized creating a sound physical infrastructure for industry, stable labour relations, a capable work force through heavy expenditures on education, vocational training and research facilities. Financial help has been provided mainly for

*This does not deny, however, that during most of the postwar period the Dutch economy has been subject to a formidable system of indicative planning.

depressed areas and declining branches of industry, through tax policy, loans or direct assistance.

Large firms play a significant role in the Dutch economy. Industrial production has relied structurally on a few firms of international stature. As home country to such powerful multinational enterprises as Philips and Royal Dutch Shell for example, the Netherlands is a heavy foreign investor. In fact, it is the third largest single source of foreign investment in the US and the fifth largest in the world. This also explains Dutch adherence to a liberal global economic environment.

The absence of any significant degree of antitrust regulation is probably a corollary of the importance of large multinational enterprises to the Dutch economy. Government ownership of industry is negligible; it holds a majority interest only in the national airways and railway systems. "Climate measures" do not even include a discernible "Buy Dutch" policy, although government has organized procurement for certain large public undertakings, notably the fight against the sea. As in most countries, public procurement and subsidies have been the mainstay of the aerospace industry. Thus, the Dutch government pledged venture capital and bank loans worth $960 million for the development of the Fokker MDF 100-passenger aircraft and contributed $94 million to the F-28 Fellowship jet.

Of more direct interest was the creation in 1977 of the Spearhead Fund with an initial allocation of $50 million for 1977 and 1978. The objective was to allow government participation in selected industries that are risky, have a long pay-back period and are involved in new technologies. Projects had to be based on advanced technology. In 1980, the Spearhead Fund disbursed $100 million, and anticipated expenditures to reach $186 million by 1983.

A quick survey of the usual specific industrial support measures in operation in 1981 reveals a wide range of loan assistance schemes, regional grants, "restructuring subsidies" of up to 20 per cent, export credits, guarantees for the costs of preparing "turnkey" projects, and various "bailing out" instruments.

In May 1978, an Investment Account Act came into effect that made $6.8 billion (1978-81) available for industrial aid over a three-year period. This measure was one of the first signs of an emerging willingness to introduce a greater degree of selectivity into Dutch incentive schemes, because it offered *differentiated* tax refunds depending on the type of investment and on whether a firm complied with certain given criteria. The Act provided for the gradual introduction of additional criteria, including energy conservation and technology and innovation.

Financial help through *fiscal tools* has been the mainstay of industrial support. Regional tax inspectors have been given a remarkably high degree of discretion, and have the ability to promote regional industrial development in an *ad hoc* manner, including *ad hoc* tax holidays. Several regional development programs facilitate industrial projects either through loans or equity participation.

However, the Spearhead Fund was one of the first signs of a policy shift in the face of economic pressures, especially since the publication of a report by a governmental think tank, the Netherlands Advisory Council for Science Policy, which pressed strongly for a strengthening of the private sector starting with manufacturing industry.[3] The Council called for more sector-specific policy measures. As a result, a high-level advisory committee to the government on industrial policy met under the chairmanship of a former chairman of Royal Dutch Shell, and advocated specific measures for re-industrialization, including a corporation for industrial projects, which would provide risk capital on a commercial basis, with at least $480 million to be expended in the first three years.

Research and Development

Industry in the Netherlands has tended to be strongly self-reliant in its R&D financing, with the five largest companies undertaking up to 80 per cent of total industrial R&D each year. The government's contribution to R&D takes place under the aegis of a formal "science budget," with much of the money having been channeled into nuclear, aerospace, computers and defence, the so-called "big science" projects. Technical industrial development credits have gone mainly to large companies, to develop new products and processes. Up to 70 per cent of costs incurred before commercial exploitation can be subsidized; the interest rate is only 5 per cent. An Industrial Guarantee Fund for innovation guarantees loans of up to $5 million per project; the Fund has an annual capacity of up to $50 million. The government-controlled National Investment Bank also guarantees high-risk loans under a Special Financing Program that has occasionally provided very large loans to major firms.

Institutes like the government-subsidized Netherlands Organization for Applied Scientific Research (TNO) undertake much industrial innovation. Up to 50 per cent of TNO's research is government-financed. The industrial research division alone employs almost 1800 people. Assistance spans all phases of the innovation process, short of production. In 1976, TNO added a staff group for strategic surveys, including a central marketing section. Instrumentum TNO, for example, works on advanced electronics, including the design of microprocessor applications. By 1978, TNO's budget had reached $280 million, of which the government contributed one half. This type of "indirect" expenditure through an intermediary such as TNO underlines the fact that in 1979, for example, 66 per cent of the government's expenditures on applied research to promote industrial development ($190 million) was indirect. In contrast, as reported by the Advisory Council for Science Policy in the previous year, direct aid to industry for R&D was four to ten times lower than in the majority of industrial countries, the indirect contribution being relatively larger than anywhere else. Even then, the Council had pressed for more direct R&D support, with a "special-purpose component going to certain branches."[4]

In 1981, the government spent $1.6 billion on R&D. And although the science budget was expected to rise to $820 million in 1982, government still relied on industry to contribute the lion's share of industrial R&D, furnishing only a little over one-third of estimated industrial R&D expenditures of $2.3 billion in 1982.

Electronics

A White Paper on Innovation Policy, issued in October 1979,[5] placed considerable emphasis on microelectronics, recommending that applications of the technology be made available to small and medium-sized firms, and calling for increased collaboration among research organizations as well as with industry. The government had commissioned a special report on microelectronics from an advisory group chaired by Professor Rathenau of Philips, with the help of General Technology Systems Limited of the UK. The Advisory Group Report included a wealth of technical detail and insight.[6] It concluded that the large-scale introduction of microelectronics over the next decade must be regarded as one of the most important external influences on the Dutch economy and that the government should take steps to ensure that microelectronics constitutes an important component of future investment. Among the required measures would have to be special government support for the advanced design of components and systems, and greater support of suppliers in the local market through procurement.

At the same time, the report was ambivalent in advocating the need to keep options open, to establish yet another centre for expertise and design, to inform businesses of their options, to evaluate periodically Dutch expertise in the field, to specialize in software and to support international standardization of interfaces and software. This ambivalence was illustrated by the fact that, out of the total budget for innovation recommended by the White Paper, expenditure for the application of microelectronics would only rise from a mere $3.5 million in 1980 to $5–7 million in 1984. Other reasons may have contributed to the reticence of the Advisory Council report, for the underlying study by General Technology Systems left little doubt about the urgency of the challenges ahead: "There is a high degree of consensus among Western European governments that national industries have no choice but to utilize microelectronic technology if they want to keep up with their industrial competitors."[7] The winners and losers in future markets will be determined by the degree of commitment and success in this field.

Practice and Implementation

The Investment Climate

Competitive international pressures in high technology have only highlighted the ambivalence of public policy making in the Netherlands. It is not surprising to find that official and semi-official thinking has taken off in often diametrically opposed directions. Numerous reports and the activities of many committees of inquiry, often coupled with indecisive and occasionally recriminatory debates in the legislative assembly, have accompanied plans to "re-industrialize" the country.

A well-informed analyst of Dutch industrial development claimed that while the country is growing more interventionist, too many diverse government measures influence firm behaviour (apparently a total of no fewer than 130 instruments). The feeling is those measures need to be simplified and consolidated. However, he discerns general disappointment with macroeconomic policies and with underlying economic statistics, which are so unreliable that they inhibit intelligent policy making.* Due to a lack of strategic thinking and despite numerous reports, too little has happened in the development of key technology areas. For him, merely to distinguish between large and small firms or between new and old enterprises is no longer enough for intelligent industrial and economic planning. The analyst accused the Ministry of Science Policy, in particular, of "too many discussions and too little action."[8]

By 1981, it was still unclear whether the government would shift from nonselective industrial support to more direct intervention in a manner even remotely comparable to the selectivity of the French model. The Dutch still appeared to be thinking in broad functional terms (cost and risk reduction, general diffusion of knowledge). Even with respect to key technologies they were reluctant to guide private sector action, instead supporting firms that had themselves decided how to innovate and commercialize.

Small Businesses

The predominance of multinational enterprises (five of which, during recent years, accounted for up to 80 per cent of Dutch industrial

*A similar complaint about OECD statistics surfaced during interviews in Sweden.

research) may have much to do with the foregoing observations and may also explain the increasing concentration of specific government-inspired activities on the needs of small and medium-sized enterprises. Another reason for more small business support has been the discovery that, since the beginning of the 1970s, the European ratio of the growth in industrial output to the growth in employment has been markedly negative; it is felt that small firms are better placed to counteract this trend than are large firms.

The Dutch recognize the need for a greater awareness of the positive role of government *procurement* in boosting the small business sector, especially in Europe where governments have been notorious for their preference to buy from reliable large firms. The renewed interest in small and medium-sized firms has been most noticeable in the operations of a unique institution, the Mikrocentrum in Eindhoven (an independent foundation with 200 member firms; of whose nine member board of directors, no fewer than five are from the giant Philips company). The Centre's objective (an offshoot of the Netherlands Society for Fine Mechanical Technique (NVFT)) is to improve the ability of highly technical small businesses with high standards of craftsmanship to exploit their strengths in a "learning environment." The emphasis is on the applications end of technology, at the level of the firm rather than the technology itself. Microelectronics has been receiving increased attention. The Centre offers such innovative services as assistance in persuading banks and financial institutions to supply financial aid. An exhibition centre helps member firms display and sell their products. To preserve quality, the Centre requires that interested companies compete to gain admission to membership; 15 per cent are foreign firms, some subsidiaries of large firms. Even more attention will be given in the future to quality standards with the creation of a central institution to be run by companies (with government support), which will educate its members, test products and even act as a clearing house for complaints.

The Mikrocentrum also harbours the Netherlands Aerospace Group (NAG), which was formed to help small firms align their expertise with the requirements of the F-16 fighter procurement program. With a government loan of over $250 000, the Centre helped members of the Group to raise their quality standards to the required levels and band together for discussion and tendering. Here was a case of building from below rather than waiting for the big contracting companies to impose requirements from above. Small firms also learned how to deal with large firms, and became well enough placed to inject themselves into negotiations for the international development of a new 150-seat civilian aircraft. Eventually, the Centre organized its microelectronic interests into the Netherlands Microelectronics Group (NEMG), with 35 knowledgeable member companies having joined by 1981. They develop joint research programs for subsequent submission to the government or to large firms like Philips.

Large Firms

In its dealings with large firms, the Dutch government appears to have maintained a high degree of flexibility. The old system of development credits is still the basic model for intervention, offering loans of up to 70 per cent of project costs. Significantly, even when the loans do not exceed 40 per cent, as in the case of quite large firms, the contract conditions do not vary. The interest rate is substantially below market rates. Loans are only repayable from the results of the projects for which they are granted, within four to six years of successful commercialization. But, most astutely, repayment must come from the *gross* revenues of a project, not from the project's profits, "otherwise there may never be a profit warranting repayment."[9] Funds are applied to the middle phase of innovation, namely, after basic research but before commercialization. An innovation must not only be novel for the company concerned, but also for the country.

Another sign of astuteness on the part of the authorities is that a large firm, qualifying for no more than a 40 per cent loan, is measured by the size of its worldwide payroll (affiliates included). Government is truly flexible in its attitude to the recipient company's ownership and use of the new technology. In the words of a private sector spokesman:

> "Governments have to be liberal when it comes to patent and know-how policy; they are simply not equipped to manage the use of technology... . It is when civil servants get involved in such things (as in France) [that] one finds shameful waste of public money on unwise projects."[10]

Government officials appear to acknowledge the futility of trying to monitor technology flows effectively, and are reconciled to accepting that "firms are normally willing to use the results of such developments for their own benefit and therefore for the benefit of the country."[11] In some cases, "firms simply have to merge with foreign companies and in that case they ought to be able to produce elsewhere in the interest of the overall efficiency of the joint venture."[12] To prevent too much money going to large firms, the government has limited their development credits by earmarking about 60 per cent of available funds.

Selectivity

While the development credit scheme is relatively short term, the Spearhead Fund is more selective, and it also takes a longer view. Financing flexibility results from the possible mixing of credits, subsidies, guarantees and even government equity participation. The government seeks, in particular, spin-offs from high technology ventures, and marketing prospects seem to play a prominent role.

As far as mechanisms are concerned, an interesting method of cash payments, administered through the tax system, was introduced in 1978.

The most up-to-date development is a new company, the Society for Industrial Projects (MIP), established in 1981 to raise $160 million on capital markets each year and to provide venture capital for advanced, risky projects. The company's reigning philosophy is admitted to be devoted to "picking winners." The board of directors will operate independently;* once the government has approved MIP's budget, the board will be free to go its own way. The various regional development authorities in the Netherlands will be obliged to offer MIP a chance to participate in all new projects. Here is another example of the types of intermediate agencies increasingly employed to deliver incentives for innovation.

Overview and Prospect

Greater government activity in the promotion of microelectronics was evident at the beginning of the 1980s, with a considerable quickening of pace by 1981. In that year the Netherlands Study Centre for Technology Trends produced yet another thorough overview of the expected role of microelectronics in professions and industries. As well, Professor Rathenau noted that, "once you have opted for microelectronics, as the government now has, a bold approach is needed. It cannot be done with inadequate manpower and resources, and it is not enough just to follow developments. In the industrial field it is important to ensure that we move to the forefront."[13]

In July 1981, the Minister of Economic Affairs announced special microelectronics incentives for small and medium-sized firms employing fewer than 500 people. The incentives would subsidize consulting, up to a maximum contribution of $4800; issue loans for up to 70 per cent of project costs, with a maximum of $120 000, at 5 per cent interest; and give special consideration under existing programs for microelectronics activities. However, the total amount of promised financing was still relatively small.

The promotion of microelectronics has been extensively debated in the Lower House of the Dutch parliament, where much dispute

*It is interesting to note the committee that recommended the new organization underlined the need to hire managers who will be well paid by international standards.

has ensued concerning the location of a proposed microelectronics centre. Parliamentary critics expressed disappointment that the government intended to commit only $40 million to special support for microelectronics in 1981. However, one must remember that the government directed support measures towards small enterprises, and would continue to disburse indirectly a very large proportion of public subsidies into activities where microelectronics would receive growing attention. In many ways the new Dutch initiatives resembled the British MAP.

By the end of 1981, other national institutions were becoming more active. A regional development corporation in the province of Overijssel financed the start-up of small companies to develop custom-designed integrated circuits. TNO produced well-illustrated guides to financing and technical information for businesses interested in microelectronics. The long-established Mikrocentrum in Eindhoven provided special exhibitions and other services. Like Sweden, the Netherlands has a strong tradition and base in the kinds of craftmanship that will be vastly affected and improved by the microelectronics revolution.

We conclude that the perceived lack of enthusiasm and experience in the Netherlands with regard to direct forms of intervention is partly a reflection of the paucity of detailed information on delivery mechanisms. Growing interest in helping small firms runs hand-in-hand with a relationship between government and a few large firms that is as ambivalent and as hard to define as the overall public policy approach to investment and innovation. Given this ambivalence and the conviction that more direct initiatives are required, it is perhaps not surprising that one of the few noteworthy recent developments is an increasing interest among trade unions in becoming more knowledgeable about the microelectronics revolution. By 1982 there was evidence of a growing awareness that government could no longer afford to stay as inactive or dispassionate as it had been about the need to intervene more positively in the promotion of the new technologies. The Dutch had finally woken up to the challenges of the microelectronics revolution. A leading politician summed up the situation as follows:

> "It is like a gold fever; those who are not moving fast, will miss the boat. Those who fail to take a lead, are forever left behind; those who fail to join the race, are forever handicapped."[14]

VIII. Postscript

As is evident from the countries studied, very substantial commonalities and similarities exist among European approaches to the support for the new technologies. A high degree of awareness was found not only in each country, but also at the level of the EEC. As far back as the early 1970s, special funding programs for investment and innovation in microelectronics had been launched. These programs reflected an even earlier commitment to promoting the electronics sector in general; in some cases, support was a natural outgrowth, or feature, of earlier national schemes to foster excellence in computer design and computer applications. Towards the end of the decade, the focus began to shift from computing and communications to other applications, especially manufacturing processes. In several cases, 1978 stands out as the year when governments became most visibly committed to the promotion of the new technologies.

Government spending on microelectronics could not easily be distinguished from the broader support of electronics, not to mention the funding of investment and innovation in the defence and aerospace sectors. The vital role that public procurement plays in these sectors, as well as in telecommunications, is common knowledge. Even though an examination of procurement was beyond the scope of this study, its role alone must qualify the non-interventionist claims of any government.

As well, microelectronic-support expenditures could not be separated from more general schemes for promoting R&D, regional economic expansion and employment. European governments have been sinking immense amounts of public resources into the maintenance of industrial competitiveness, increasingly equated with technological excellence. Horizontal policy measures have consistently been complemented by an astonishing array of direct, but nevertheless cautious, forms of economic intervention. Indeed, a "technological imperative" has demanded as much by way of "government push" as "market pull."

In summary, the degree of commitment by the countries studied is shown, first, by the amount of the public resources expended over many years, and second, by the diversity of ways in which public support has been expressed. In some cases, the responsible agencies have been prepared to incur extraordinary risks, especially in the light of other pressing and competing demands upon the public purse. But above all, the sense of concern has been manifested by a ceaseless and energetic pursuit of alternative, better ways of mobilizing national resources and meeting competitive threats. Need has been equated with national survival. Success, it seems, is not so much a function of detail as of motivation - a national consensus and national commitment to meet the industrial competition of the 1980s.

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