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I. INTRODUCTION

The international economic crisis of 1974-75 represents a turning-point in the economic and political development of post-war Western Europe. Although the long post-war 'boom' had already begun to run out of steam in the middle and late 1960s, since 1974-75 Western European states have had to cope with a growing number of increasingly intractable structural and conjunctural economic problems. These have included rising energy prices, intensified competition on the world market from newly-industrialising third-world states in the lower-technology industrial sectors, the growing saturation of the market for some major consumer goods, and the coincidence of stagnant, or even contracting, production with historically high rates of price-inflation, trade deficits, and a less and less sustainable burden of state indebtedness. The coincidence of these latter phenomena in particular has given rise, in degrees of intensity varying from state to state, to a crisis of the Keynesian philosophies of economic management which exercised a dominant influence on economic policy-makers in most Western European states following the Second World War.

The progressive erosion of the Keynesian paradigm of economic management has been accompanied by growing efforts by governments in the major Western industrial states (and Japan) to stimulate technological innovation. The expectation that accelerated technological innovation could generate more rapid economic growth and create new jobs has been expressed repeatedly, for example, in the

communiqués agreed by the leaders of the major capitalist-industrial states at their regular economic summit conferences.

This paper constitutes a preliminary attempt to compare state actions to promote technological innovation in the three largest Western European industrial states, West Germany, France and Britain. It deals exclusively with state actions to promote technological innovation in the storage, processing and transmission or communication of information. The most significant recent development in information technology has been the emergence of micro-electronics, which, more than any other of the 'new' technologies, has, given the immense range of its potential applications, the character of a key or 'basic' technological innovation (Cf. Friedrichs 1982, 201-02 and King 1982, 24). The development of micro-electronic technology opens up possibilities for the manufacture of new products (for example, the pocket calculator and the personal computer) or the modification of existing ones and for the rationalisation of manufacturing and production processes (for example, through the introduction of industrial robots and computer-aided design and manufacturing). The former may be described as 'product-innovations' and the latter as 'process-innovations', whereby certain investment goods, such as industrial robots, may simultaneously be both product-innovations (for their manufacturers) and process-innovations (for their appliers) (Cf. Friedrichs 1982, 218).

This paper is concerned with state initiatives to promote the development of information technology and technological innovation in

the major actual or potential spheres of application of micro-electronics and other new information technologies (e.g. fibre optics): computing, data-processing and office machinery, telecommunications, and manufacturing and production techniques. [1] The next section of the paper is devoted to an examination of the motives of state intervention to promote technological innovation, particularly in the information technologies, in Britain, France and West Germany. In the third section, the origins of British, French and West German information technology policies (before the 1974-75 economic crisis) are briefly investigated. The fourth section of the paper attempts to compare, primarily in financial terms, the 'scope' and structure of British, French and West German information technology policies since 1974. In the conclusion, some remarks are made as to the sources of similarities and differences in information technology policies in the three states and as to whether the new information technologies shall or can fulfil the employment-generating role attributed to them by their political sponsors.

II. MOTIVES FOR THE STATE PROMOTION OF INFORMATION-TECHNOLOGICAL INNOVATION IN BRITAIN, FRANCE AND WEST GERMANY

State 'strategies' to shape the restructuring of industry have mushroomed in Britain, France and West Germany since the 1974-75 economic crisis. The 1974-79 Labour government in Britain purported to have an 'industrial strategy', the Giscardian regime in France a strategy for 'industrial redeployment', and the biggest governing party in West Germany up to 1982, the SPD, a strategy for the

'modernisation of the economy' (Modernisierung der Volkswirtschaft). State intervention to promote the development and application of the information technologies has formed one component of these 'strategies' (a term which may disguise a considerable lack of internal policy coherence) in all three states. Despite its promises to roll back the frontiers of the state, the Thatcher administration built on the succession of initiatives of its Labour and Conservative predecessors in laying strong emphasis on the promotion of the so-called 'sunrise' industries, especially those based on the new information technologies. In France, data-processing machines and telecommunications equipment were designated as top-priority sectors for state support in 1976, to be followed in 1980, with the Giscard-Barre government's strategy for strengthening French industry, by office technology, consumer electronics, and robotics (Green 1981, 344). The Left coalition government of the Socialist and Communist parties has retained these priorities: the electronics industry was made the "industrial priority of the ninth (Economic) Plan" (Mitterand in Ministère de la Recherche et de l'Industrie 1983, 417.) [2] "Industrial modernisation through new technologies" and the "stimulation of research and innovations" were ranked first and third respectively in the plan's 12 'priority programmes' (Cf. Le Monde 16.9.1983 and 21.9.1983). The West German Social Democrats' industrial modernisation strategy aimed to increase the level of specialisation of German production in the high technology industries such as electronics (Cf. Matthöfer 1976, 68-69 and Hauff and Scharpf 1977, 38-41.)

The information technology industry produces between three and four per cent of total output in Britain, France and West Germany. In the latter two states it employs around one and a half per cent, and in Britain just under one per cent of the total labour force (Cf. Ministère de la Recherche et de l'Industrie 1982a, 4 and appendix 5, Deutscher Bundestag 1983, 35 and NEDC, 1982.) The output of the industry has grown significantly faster than overall production since the early 1970s and is expected to continue to do so. These facts alone, however, do not adequately reflect the importance of the information technology industry for the future economic development of the Western European and other industrial states. The significance of the new information technologies is seen to exist primarily in their cross-sectoral range of actual or potential application and in the fact that their application will permit major cuts in production costs and increases in productivity and possible enable the firms (and economies) which apply them most rapidly and efficiently to steal a decisive advantage over their competitors on the domestic and international markets (Cf. Friedrichs 1982, 201).

The belief that information-technological innovation is, and will continue to be, a major engine of economic growth and employment creation has been an important motive, but only one of a number of motives, for state intervention in the information technology industry in Britain, France and West Germany. [3] Why must the state intervene to promote or support what is, in any case, a growing industry? The British, French and West German economies are all relatively open and are tightly integrated into the international division of labour. All

three are dependent to a great, if varying, extent on imported raw materials and have highly export-oriented production apparatuses. In 1981, West Germany and Britain exported almost 30 per cent and France about 25 per cent of their respective national outputs. For such states, the pursuit of an autarkic economic strategy may be virtually impossible: their economies and firms must swim, or sink, on the world market. If their economic life is not to remain, or become, based on low or old-technology industries and production processes (in which case they will confront increasingly intense competition from the newly-industrialising states and have to make do with stagnant, or probably declining, living standards), these states may have no choice but to try to develop and apply the new information technologies. [4] The British, French and West Germany information technology industries have, however, lost ground on the world market to American and Japanese competition. In the period since 1974-75, all three states' trading balances in information technology products have worsened (Deutscher Bundestag 1983, 36; Wirtschaftswoche 27.1.1984; Ministère de la Recherche de l'Industrie 1982a, appendix one; Nivollet 1983, 42; NEDO 1982, 60). The world market for most branches of the information technology industry is dominated by American and Japanese producers (Cf. NEDO 1982, 60 and BMFT 1984a, passim). Thus, a further motive of state intervention to promote information-technological innovation has been the growing (or rather renewed) perception among policy-makers in Western Europe of an 'information-technology gap' between Western Europe and the United States as well as, increasingly, Japan and the associated fear of a loss of industrial competitiveness accompanied by the destruction of indigenous capital, stagnating or

declining material living standards, rising unemployment, and growing economic dependence. [5]

One of the factors which has been identified as a principal determinant of American technological superiority vis-à-vis Western Europe is the massive state financial support of the American information technology industry, especially through the space and military budgets. According to one source, some 37 per cent of all research and development expenditure in the American electrical engineering and electronics industry in 1981 was financed by the state, excluding state grants for military research and development (Luft 1983). Of the West German total (which was only a quarter of the American sum), only 13 per cent was state financed and of the French (in 1980) 28 per cent (Ibid. and Projet de Loi 1983, 210). In West Germany, state subsidisation of the information-technology industry has been explicitly justified by reference to the aid given to the American industry through the military budget - both currently and in the 1960s (Cf. Hirsch 1970, 118 and 180; Neuendorff 1974. 148; Luft 1983; von Bülow 1981, 16; Handelsblatt 30/31.12.1983).

State promotion of technological innovation in West Germany has also been justified by the perceived failure of private capital to undertake innovative technological research and development on account of the "high level of risk" involved in the development of certain 'new' technologies, the too high costs of such research and development for individual firms, and the expectation of the firms that, given short-term demand projection, investment in such research

and development would not prove profitable (BMFT 1979, 28) These factors inhibiting the investment of private capital in technological innovation may have been no less present in the information technology industry as in other industries. In particular, the smallness of the Western European markets and the comparatively small size and capital base of Western European information technology firms may, together with the high costs of information technology research and development, limit their research and development capacity compared with that of the Japanese and American firms and make them structurally more dependent on state financial support than their Japanese and American rivals (Cf. Neuendorff 1974, 145). The research and development budget of the American firm, IBM, alone is five times as great as that for the entire French information technology industry (Projet de Loi 1983, 17).

The information technology industry is also one in which the state has a strong 'original interest' in the promotion of technological innovation (Cf. BMFT 1979, 28). The application of computers and electronic data processing equipment in the state administration may, for example, increase the scope for raising productivity and curbing personnel expenditure, thus easing state fiscal problems (Cf. Matthöfer 1976, 135). In France, Britain and West Germany, the state has traditionally been responsible for the provision and maintenance of the telecommunications infrastructure. The state's interest in stimulating information-technological innovation is especially strong in the military sector. The quest for military ascendancy among the world superpowers has been one of the

principals spurs to innovation in the information technologies (Cf. King 1982, 13 and Barnaby 1982, passim.) Within Western Europe, France's maintenance of an independent nuclear deterrent has provided the French state with a powerful motive for developing and preserving an independent information technology industry. [6]

Moreover, the promotion of the military application of information technology may have positive 'spin-off' effects for the 'civilian' economy, while military equipment itself constitutes a 'growth market'. Not only France, but also Britain and West Germany have become increasingly prominent suppliers on the world market for (above all sophisticated) armaments and weapons systems (Cf. Huffschmid 1981, 154).

III. INFORMATION TECHNOLOGY POLICIES IN BRITAIN, FRANCE AND WEST GERMANY BEFORE 1974

While the post-1974 economic crisis and the crisis of Keynesian economics may have provided a major impulse to the expansion of supply-oriented state measures for industrial modernisation and restructuring in Britain, France and West Germany, the involvement of the state in the information technology industry in all three countries - as is clear from the foregoing general portrait of the motives of state intervention in the industry - pre-dates the economic crisis. Indeed, it might be argued that, in certain branches (such as telecommunications technology and equipment), the state (in this example as the provider and maintainer of the telecommunications

infrastructure) has always intervened in the information technology industry. In France, Britain and West Germany, state intervention in the 'new' information technologies (especially in the computer industry first assumed a significant scale in the middle and late 1960s.

French state intervention in the information technology industry was precipitated by the decision made in 1964 by the leading French computer manufacturing firm, Bull, to go into partnership with the American company, General Electric (Mazataud 1981, 29). Within the French government, there was, according to Zysman, a pervasive fear at this time that France was becoming technologically backward vis-à-vis the major Western industrial states (Zysman 1977, 74). In particular, however, the French did not want to become dependent on the United States for the computer technology necessary for the development of their own nuclear strike force. The Bull company's decision and the United States' ban on the export to France of big computers with a possible military application were the immediate motives of the government's formulation of a programme of aid for the computer industry which ran from 1966 to 1970. Under this first Plan Calcul, the computer manufacturing activities of the five main French electronics firms, other than Bull, were merged into two companies, Sperac and CII, which the government supported with aid worth Fr. 420 million.

Up until 1970, however, the Plan Calcul was not conspicuously successful. The domination of the French computer market by such

American firms as IBM continued to grow. With less than one per cent of the world computer market, CII was still far too small in 1970 to be able to make a profit and it therefore remained dependent on state aid for its survival. In a second Plan Calcul (1971-76), state financial aid to CII was stepped up. Indeed, the state pumped far more money into the company than did its parent companies (Mazataud 1981, 43). At the same time, the government encouraged the development of links between CII and major foreign (initially European) computer manufacturers. These efforts led to an agreement between CII, Siemens and Philips to produce a common range of computers, with each firm specialising in the manufacture of particular models (Ibid., 31). However, this union proved short-lived, collapsing in 1976, when the French government approved CII's merger with the firm, Honeywell-Bull, which had been created by Honeywell's purchase of General Electric's shareholding in Bull in 1970. The government agreed to grant the new firm Fr.1.2 billion over the following four years within the framework of a third Plan Calcul and to guarantee it orders worth more than Fr.4 billion (Ibid., 44).

In West Germany, state intervention to stimulate technological innovation was confined up until the late 1960s largely to the nuclear energy, aerospace and defence sectors. State expenditure in these sectors had risen rapidly after West German re-armament had begun and the Federal Republic had been permitted in the mid-1950s to recommence aircraft production and to start producing nuclear energy (for non-military purposes) (Hauff and Scharpf 1977, 77 and Hirsch 1970, 168-69). The relative underdevelopment of West German technology policy

is illustrated by the fact that, in the middle to late 1960s, only about 17 per cent of all West German industrial research and development was state-financed, compared with 31 per cent in France, 37 per cent in Britain and 52 per cent in the United States (Hirsch 1970, 165). In the latter three states, the electronics industry was a principal beneficiary of state research and development subsidies already in the early 1960s. The American military and space budgets financed almost two-thirds of the total research and development outlay of the American electronics industry in 1963-64 (Ibid., 180). While the British and French electronics industries received 36 and 30 per cent of state research and development subsidies in their respective states, only four per cent of the state budget for research and development flowed to the electronics industry in West Germany (Ibid.).

The 'technological gap' between the United States and West Germany which caused increasing concern in West Germany in the late 1960s was widely attributed to the Americans' massive state financial engagement in the researching and development of the new information technologies (Cf. Ibid., 103). The first West German programme of state aid for the data-processing industry could thus be interpreted as a kind of surrogate for the support which this industry received abroad through the military research and development budget (Ibid., 118).

Launched almost simultaneously with the French Plan Calcul, this first programme ran from 1967 to 1970 and was worth some DM 353

million, of which about DM 200 million was allocated for the support of research and development within the industry (Schmidt and Stoltenberg 1978, 702). The Social-Liberal coalition which assumed office in 1969 boosted support for the industry strongly. The second data-processing programme formulated by the Research and Technology Ministry provided for expenditure of DM 1.8 billion over the period from 1971 to 1975. Some 40 per cent of the aid flowed into industrial research and development, 31 per cent into promoting data-processing applications, and 21 per cent into programmes in higher education. The revised priorities of the new programme reflected the government's objectives of expanding computer facilities in higher education and training more data and computer technicians (Ibid). The primary beneficiaries of state aid were the two biggest West German electronic firms, Siemens and AEG Telefunken (Cf. Section IV.2). In the belief that the West German economy was too small to sustain a computer manufacturer large enough to be able to produce a full range of data-processing systems and to stand on its own two feet in the international market, the West German government also approved the temporary joint venture of Siemens, Philips and CII in 1973 (Cf. Hauff and Scharpf 1977, 88-89).

In Britain, the National Research and Development Corporation began granting financial support for technological innovation and the exploitation of inventions in 1949. Although the computer industry was one of the beneficiaries of such support, the first significant selective state intervention in the industry did not occur until the mid-1960s. After manufacturing probably the first commercially

successful British computer in 1964, the ICT company ran into financial difficulties in the following year, as other British firms had done earlier. Of the eight British computer firms which had operated since the Second World War, only three still survived in 1965. The financial problems of the company almost coincided with the election of the Labour government, whose leader, Harold Wilson, had pledged to modernise British industry in the 'white heat of the technological revolution' and had established a Ministry of Technology on his election in 1964. Although Wilson feared even at the time that government intervention in the computer industry had come too late and that "time was not on our side", the government committed £4 million to ICT in 1965 (Wilson, 1974, 31). The Minister of Technology announced that, in the government's view, it was essential that "there should be a rapid increase in the use of computers and computer techniques in industry and commerce, and that there should be a flourishing computer industry" in Britain (Murphy 1982, 21).

Shortly afterwards, the recently-created Industrial Reorganisation Corporation, which was a major instrument of the Labour government's policy of selective industrial intervention, facilitated the merger of the two remaining British computer firms, English Electric and Elliot Automatic. This company was merged in turn with ICT in 1968 to form ICL, which the government supported with a £13.5 million grant and a loan. In 1969, ICL still had a 40 per cent share of the British computer market.

The Labour government's support for the company had been designed

to assist it in its competition with IBM and the other American computer firms. The intensity of the American competition - and the growing demand for new computer products - also prompted the Conservative government under Heath to continue this policy of supporting ICL. It granted ICL £14.2 million for research and development in 1972 and a further £25.8 million, designed to last the firm until 1976, a year later. To give the firm an additional boost, the government also introduced a policy of preferential purchasing in favour of ICL machines (Cf. Murphy 1982 for details). Also in 1972 the Government introduced incentives for the production of computer software, but these had very little take up until almost a decade later.

A prime purpose of state intervention in the information-technology industry in France, Britain and West Germany before the economic crisis of 1974-75, was thus to protect a nascent indigenous industry from destruction by, or subordination to, foreign, above all American, competition. State aid generally took the form of grants for research and development investments, together with, at least in Britain and France, if not also in West Germany, the adoption of preferential purchasing policies for domestic firms. Where the domestic industry was not already dominated by one or two large firms, as it was in West Germany, the state played an active role in promoting the restructuring of the industry to create one or two large 'national' firms which it was hoped would be big enough to be able to compete on both the domestic and international markets. These firms in turn virtually monopolised state financial aid for the information-

technology industry.

IV. INFORMATION TECHNOLOGY POLICIES IN BRITAIN, FRANCE AND WEST GERMANY FROM 1974 TO 1984.

The British, French and West German states, together with the EEC, command, of course, manifold potential instruments for promoting innovation in the information and in other technologies. As well as the granting of direct financial aid, these instruments include, for example, changes in ownership (nationalization/privatization) of organisations in the field (see Moon and Richardson 1984b), competition or merger policy (liberalization/cartelization), trade policy (the erection or removal of protective tariffs), the promotion of the training of skilled labour-power for the industry (see Moon, Richardson and Webber, 1984), the encouragement of co-operative research and development between indigenous and foreign firms, the promotion of technology transfer between firms and between institutions of higher education and firms, assistance for firms in product-marketing, and promoting the establishment of high-technology firms. Such instruments may involve no or little state expenditure. This discussion deals largely, however, with the scope and structure of state financial aid for the information-technology industry - which we hypothesise to be the most important dimension of state information-technology policies in Britain, France and West Germany. It compares firstly the volume of such aid in the three states, secondly the distribution of such aid, and thirdly the degree of 'selectivity' of the aid (the degree to which the state specifies or

determines the nature of the purpose to which the aid is to be put, on both an inter- and intra-industry basis). Lastly, the role of the state as a producer and consumer in the information-technology industry is investigated.

1. The scope of state financial aid to promote information-technological innovation.

The comparison of state expenditure to promote innovation in the information technologies presents more or less intractable problems posed by the lack of comparability, inclusiveness and transparency of official statistics. Unless otherwise specified (as in section IV.3), the financial aid referred to in this section is that which is or has been given in programmes which apply exclusively to the information-technology industry and therefore excludes financial assistance enjoyed by firms within the industry under the rubric of, for example, regional policy, labour market policy, and taxation policy. [7]

The incompleteness of official statistics also precludes our identifying the full magnitude of state aid for information-technological innovation which is distributed through military budgets for research and development. There are, however, strong grounds for believing that such aid is very substantial.[8] In 1981, some 52 per cent of British, 36 per cent of French and nine per cent of West German state expenditures on research and development were allocated to the military sector (BMFT 1982, 402). In France, some Fr.2 billion, or about 23 per cent, of state financial assistance to the

electronics industry in 1984 will come from the military budget and the electronics industry is the recipient of some 27 per cent of all military research and development expenditure (Le Monde 4.2.1984 and Project de Loi 1983, 34). In 1979, West German Defence Ministry research and development grants to the two biggest electronics firms, Siemens and AEG (the firms with respectively, the second and third biggest armaments turnovers in West Germany), totalled DM 62.6 and DM 145.5 million respectively (Huffschmid 1981, 107). These sums amount, respectively, to 42 and 142 per cent of the grants listed for the two firms' 'civilian' information-technology research and development work in the Research and Technology Ministry's 1981 grants catalogue. However, as both Siemens and AEG are both conglomerate enterprises active in a wide range of industrial branches, it is not possible to ascertain the extent to which the Defence Ministry grants finance the firms' research and development work in the information technologies. Certainly the role of the military as a sponsor of research and development in the information-technology industry is much more significant in France and Britain than in West Germany. Depending upon the volume of its orders in proportion to the industry's turnover, the military may also be able to influence firms' research and development and production programmes in its capacity as a consumer of the industry. In Britain, the Defence Ministry consumed almost one-fifth of the total production of the electronics industry in 1983-84 (Miles, 1983). However, in West Germany, over the period from 1974 to 1978, military orders accounted for only 1.6 per cent of the turnover of the electrical engineering and electronics industry (Hirsch, 51). The paucity of information on military research and

development programmes also precludes any attempt to evaluate their possible 'spin-off' effects for civil applications of information technologies.

Even given the inadequacies of published statistics, it is evident that state financial aid for research and development in the information-technology industry in France far outstrips that in either of the other two states. According to EEC statistics, French aid for research and development in the 'electrical, electro-mechanical and electronic engineering' sector as a whole was nearly eight times as great as the British volume in 1981 (see table one). Also in the years from 1975 to 1980, French aid for research and development in this sector was far higher than that in West Germany or Britain, where, until 1981, state aid was far below both the French and West German volumes. West German aid seems to have been relatively stable in the years from 1975 to 1979, before declining sharply in 1980 and 1981. [9] The superior quantity of French aid is most striking in the 'telecommunications equipment and electronic components' branch and in telecommunications systems. In the 'office machinery and data-processing' branch, on the other hand, there was little difference between French and West German aid in the period from 1976 to 1980. Here, too, British state expenditure was also far lower than in the other two states until 1981. The figures for military research and development expenditure underline its massive volume in Britain and, to a slightly lesser extent, in France.

While the relationships between spending volumes portrayed in

table one may have altered since 1981, especially in view of the growth of state aid for the information-technology industry in Britain, the French state still dispenses far more financial aid to the information-technology industry than either the British or the West German.[10] At a little below Fr.9 billion (around £800 million), French support for the industry in 1983 may still have been three times as great as that in Britain (Cf. below). The impressive volume of French expenditure on research and development in telecommunications reflects the gigantic programme for the modernisation of the French telecommunications network launched under the presidency of Giscard d'Estaing in 1975. This programme was followed up by the implementation of an 'informatics plan' (plan d'informatisation), which concentrated on the strengthening of the micro-electronic components branch in France. The boosting of state support for the information technologies was part of the programme with which Francois Mitterand and the Socialist Party won the presidential and parliamentary elections in 1981. In 1982, the new administration approved a five-year programme which foresaw the mobilisation of some Fr.140 billion (about £13 billion, including private capital) for investment in the electronics industry - which would have constituted a 50 per cent increase on the volume invested in the industry during the last years of the Giscard presidency (Cf. Gallois in Ministère de la Recherche et de l'Industrie 1983, 400). However, following the Left coalition's switch to a policy of economic austerity in 1982-83, it is questionable whether this programme will be implemented in its originally-envisaged magnitude. The sum of less than Fr. 9 billion allocated by the state to the industry in 1983 fell

considerably short of the Fr. 11 to 12 billion target which ought to have been met if the government were to fulfil the financial commitment it made in 1982 (Cf. Le Monde 4.2.1984). Aid in 1984 is likely to total about Fr. 10.5 billion (Ibid. and Frankfurter Rundschau 6.3.1984). Even if the 1982 programme is not realised in full, the trend in state aid to the electronics industry under the Left coalition is still upwards. Within the overall state budget for the industry, the volume of assistance for certain branches has been increased especially steeply. This applies for micro-electronic components, for which a second, much more expensive five-year programme was begun in 1982 (Le Boucher 1983). The Left government has also launched a programme for the development and application of new production techniques, such as industrial robots.

In nominal terms, the federal government's budget for research and development in the information-technology industry in West Germany rose from some DM 492 million in 1974 to a total of DM 582 million (about £145 million) in 1982 (cf. Table Two). In real terms, this represented a decline in state financial aid for research and development in the industry. The proportion of the federal government's research and development budget devoted to the information technologies declined over the period as a whole from 6.5 to 4.8 per cent. From 1974 to 1980, the information technologies' share of the research and development budget actually sank continuously, before it then rose again (in real terms as well) in 1981 and 1982.

The development of the overall budget for information-technology research and development disguises, however, major shifts in the pattern of state financial engagement in the industry. The value of state grants for data-processing, having peaked already in 1975, then declined up to 1982 - in nominal terms - by over two-thirds. After the winding-up of the Research and Technology Ministry's third data-processing programme in 1980-81, state support for the development of new products in this branch was largely suspended, with increased attention being devoted to the promotion of 'software' research and development and data-processing applications (BMFT 1982, 78). At the same time, the government stepped up its support for micro-electronics research and development, for which a first independent programme had been initiated in 1974. The main emphasis in this programme lay on the development of what were regarded as particularly 'futuristic' and promising products, such as very-large-scale integrated circuits (BMFT 1979, 53). Since 1982, the existing programme for micro-electronics research and development has been complemented by a new one designed to accelerate the product-applications of micro-electronic technology. This programme was funded with DM 450 million (about £112.5 million) for the three-year period to the end of 1984 (Cf. BMFT 1981a, passim. and Frankfurter Rundschau 27.5.1982). This more than doubled the hitherto existing state financial commitment to micro-electronic innovations. In the three years to 1982, the Research and Technology and Post ministries' support for research and development in telecommunications also more than doubled (BMFT 1982, 79-80). The growth of federal government expenditure on information-technology research and development has continued under the Christian Democratic-

Liberal coalition government. [11] Under the government programme adopted in April 1984, federal spending on information technology innovation is projected to average DM 572 million a year from 1984 to 1988, compared with DM 452 million in the period from 1979 to 1983. (BMFT, 1984a, passim, and Wirtschaftswoche 9.3.1984).

At some £50 million in 1979-80, state expenditure on the information technology industry in Britain was far lower than that in either France or West Germany. However, under the Thatcher Conservative administration, British spending rose to £231 million in 1982-83 and to a projected total of £269 million in 1983-84 (Ibid.). By 1984, state financial support for British IT innovation had overtaken the West German total. [12] Of the sum of £165 million within this total which flowed through the budget of the Department of Industry, some £30 million benefited the micro-electronics (components) branch (Jenkin in The Times, 1983). This was twice the total for 1980-81. Despite its anti-state-interventionist industrial policy rhetoric, the Conservative Party boasted that it had increased state aid for the 'new' technologies during its first term of office from £100 million to £350 million (Conservative Party manifesto in The Times, 1983, 293).

Although the post-1979 period has witnessed a major expansion of state financial engagement in the information technologies in Britain, state intervention in the industry had grown already under the Labour governments between 1974 and 1979. In 1977, the Labour government introduced a Product and Process Development Scheme which was designed

to accelerate product-and process-innovations by subsidising firms' research and development costs. This scheme was followed up by the launching of the Microprocessor Scheme (renamed the 'Micro-electronics Applications Project' in 1982) whose purposes included publicising the advantages of the application of micro-electronics in industry, providing grants for feasibility studies and the purchase of capital equipment, and assisting in the retraining of engineers and technicians. With a budget of £55 million, which was expanded in 1982 to provide £85 million between 1978 and 1983, this was, up until 1983, the biggest state programme for the stimulation of information-technology in British industry. The programme represented a reaction to widespread concern at the slow rate of diffusion of micro-electronic technology in British industry (Cf. Department of Industry 1980, 6 for amplification). It was complemented by another programme (MISP), also initiated in 1978, to support firms producing micro-electronics components by subsidising their research and development expenses, investments in plant and buildings, and product-launching and marketing costs. This was initially cut back in 1979, but expanded again in the 1984 budget. The National Enterprise Board (the major instrument of the Labour governments' industrial policy) also established three publicly-owned firms, responsible respectively for the production of micro-electronic components (Inmos), the marketing of office and business machines and communications equipment (Nexos), and the marketing of software exports (Insak).

All of the above programmes were continued by the Conservative government when it took office in 1979. Under the Conservatives, not

only the financial volume, but also the number, of state initiatives for the information-technology industry have mushroomed. Between 1981 and 1983, new programmes were launched to promote new production and manufacturing techniques (industrial robots, computer-aided design and manufacturing and flexible manufacturing systems), software and telecommunications products, fibre optics and opto-electronics. Under the 'Alvey programme', which will run from 1983 to 1988 with a budget of £200 million, the government is financing research and development work on the "fifth generation" computer. The 1984 budget saw the announcement of a further £180 million of government support for the new micro-electronic industry up until 1990. It was hoped that this aid would generate further investment worth £9 billion (The Times, 20.3.84). The government has also continued to provide financial aid to the three publicly-owned information-technology firms set up by the Labour government and, to try to facilitate a better co-ordination of government policy for the industry, has also created a Minister and division for information technology within the Department of Industry.

2. The distribution of state financial aid to promote information-technological innovation.

Measured in financial terms, then, the scope of state information-technology policy has been much greater in France than in Britain, where, however, state aid for the information technologies has been rapidly expanded, or in West Germany, where state expenditure, after a period of stagnation, is now being increased once again as well. Which kinds of firms, however, have been the principal

beneficiaries of state aid in the three states? In France, where the electronics industry consumed just over a quarter of all state aid for research and development in French industry in 1980, the main recipients of state aid have been the giant firms, Thomson, CGE and CII-Honeywell-Bull (respectively, the seventh, fifth and 41st biggest companies in France (Projet de Loi 1983, 21 and Boucher 1983, 45). These three firms were among the seven industrial groups which, in 1976, received almost 50 per cent of all state financial aid to French industry, although they accounted for less than 10 per cent of total employment (Nivollet 1983, 16). [13]

These statistics have to be viewed against the fact that, in 1980, only about 1300 French firms were engaged in research and development activities on a permanent and organised basis and that the 100 firms which employed more than 50 research and development staff were responsible for about three-quarters of the total national research and development effort (Projet de Loi 1983, 17). Nonetheless, the high level of concentration of state aid on a very few firms in the information-technology industry - which has characterised French policy for the industry from the very beginning - highlights the preoccupation of French industrial policy with the promotion of 'national champion' firms in particular industries (Cf. Green 1984, 143-48). While in the rhetoric of Giscardian industrial policy between 1974 and 1981, the emphasis was on the promotion of small and medium-sized firms, the reality of practised policy was that direct state financial assistance designed specifically to benefit such firms amounted to only about 3.2 per cent of the total (Besse

1983, 241-242). The moderate Socialist Industry Minister, Fabius, who replaced the left-wing Socialist, Chevènement, in 1983, sees small and medium-sized firms as the principal generators of new employment in the French economy (Fabius in Nivollet 1983, 38). However, such a re-orientation of French industrial policy would stand in contradiction to the Socialists' proclaimed strategy of relying upon the (now nationalized) large firms to rejuvenate the French information-technology industry.

This picture of the predominance of large firms among the recipients of state aid for information technologies is replicated, if not quite so vividly, in West Germany. A very large share of West German state aid has been claimed by the two largest West German electronics firms, Siemens (the second biggest private German company, in terms of turnover, in 1982) and AEG (the 19th biggest). Of the total sum of the project-related grants for the information-technology industry listed in the Research and Technology Ministry's 1981 grants catalogue, some 14 per cent (DM 148.8 million) flowed to Siemens, nine per cent (DM 102.5 million) to AEG, and four per cent (DM 43.9 million) to the West German sister company of the Dutch multi-national, Philips. [14] For the two branches micro-electronics and telecommunications combined, the three firms' respective shares of project-related state aid were 20, 16 and 6 per cent respectively (BMFT 1981b, 426-95). These proportions were higher at the beginning of the 1970s. Of the total aid for the data-processing programme listed in the ministry's 1971 catalogue, Siemens claimed 46.6, and AEG 48.7 per cent (Neuendorff 1974, 156). Over the entire period from

1973 to 1982, Siemens received state aid for research and development worth DM 4,211 million and AEG some DM 480 million. [15] In contrast, in the most recent year for which statistics are available (1982), only 10 per cent of state aid for information-technology research and development projects was allocated to small and medium-sized enterprises (those with a turnover of under £50 million and not largely subordinate to a big firm) (BMFT 1984b, 70).

This concentration of aid on large, or very large, firms in the electronics industry corresponds fairly closely to the general pattern of distribution of state research and development grants in West Germany (Ibid.) The main explanation cited officially for this phenomenon in West Germany is that only large firms command the resources required to carry out large-scale 'new technology' projects (BMFT 1979, 15-16). Particularly in the 1960s and early 1970s, such projects swallowed up the lion's share of state aid for research and development within industry. As they involved "great technological and market risks" and their implementation required "considerable, in some cases, highly specialised research and development capacities and a very high level of management experience", they could be allocated only to large firms (BMFT 1978, 19-20). [16] Other factors hindering small firms in claiming state research and development grants are said to be lack of knowledge about the possibilities and procedures for obtaining grants, reservations about the disclosure of company information and the administrative effort involved in making grants applications, and the lack of adequate accounting procedures for monitoring grant expenditure (Ibid., 21). However, the broadening of

the range of state research and development programmes during the 1970s and especially the introduction in 1979 of a subsidy for small and medium-sized firms' spending on research and development personnel led to a major increase in state research and development aid for such firms. [17] Small and medium-sized firms have also been the major beneficiaries of the progressive switch of emphasis in state policy for micro-electronics from the development of 'basic' micro-electronic technology to the application of the technology in new products. According to a preliminary analysis of the micro-electronics applications programme initiated in 1982, around 85 per cent of aid granted under the scheme flowed to small and medium-sized firms (VDI-Technologiezentrum 1983, 16-17).

No official data are published or available on the distribution by firm size of state financial aid for the information-technology industry in Britain. The concentration of state aid for the computer and data-processing branch on ICL and its predecessor companies in the 1960s and early 1970s suggest that the distribution of British state aid for the industry at this time at least did not differ essentially from that which prevailed in France and West Germany. However, this need not apply for the numerous programmes which have been launched for the industry since the late 1970s. Certainly, the three information-technology companies established under the Labour government by the National Enterprise Board have been among the biggest beneficiaries of state aid for the industry.

Apart from the tendency in West Germany and France, if not also

in Britain, for state aid to be concentrated on a small number of usually large firms, the other striking characteristic of the distribution of such aid for the information-technology industry in the three states is that it has flowed mainly to domestic-owned or controlled companies. Above all, the leading American multi-national information-technology companies have, with some exceptions (especially where, as in the case of CII-Honeywell-Bull in France, they have formed partnerships with local-based firms) received relatively little state aid for information technology research and development.[18] The most prominent exception to this pattern appears to be Philips, whose research and development work has been supported by the state in both West Germany and France (Cf. Section IV.1 and Projet de Loi 1980, 58). The practice of generally excluding foreign-owned firms from the receipt of state aid tends to confirm the suspicion that aid to promote innovation in the information technologies is often used as an instrument for the protection of indigenous firms from competition, or the threat of destruction, by American and Japanese companies.

3. The mode of state financial aid to promote information-technological innovation

Patterns of state financial aid to the information-technology industry may also be distinguished according to the degree of 'selectivity' (or specificity) of the aid. State aid offered exclusively for the development/and or product- or process-applications of particular technologies considered by state organs to

be important or worthy of support may be classified as selective. Such aid is all the more selective, the more closely the state specifies or determines the nature of the purpose to which the aid for a particular technology is to be put. Whether it is made available in the form of cash grants or tax allowances, other state aid (such as, for example, assistance for newly-established firms or for the general research and development activities of firms, irrespective of the branch or industry to which they belong) may be classified as general. In the real world, most state technology policies will combine both selective and general policy instruments. The balance of state aid as between selective and general policy instruments or programmes constitutes one significant indicator of the character and 'depth' of state intervention in the information-technology industry. In principle, it is possible to envisage a situation in which the absence of a high level of selective financial aid for firms, or particular firms, in the information-technology industry is compensated for by generous general provisions for subsiding firms' research and development work, irrespective of its contents.

French information technology policy, has, however, been predominantly selective in character. Even under the first Plan Calcul in the 1960s, French state intervention in the computer industry was notable for its particularly detailed and selective character. Agreements were negotiated between the state and sponsored firms as to which range and types of computers the firms were to produce (Mazataud 1981, 42). This comparatively high degree of policy selectivity seems to have been a stable characteristic of French state

policy, despite the liberal and anti-interventionist rhetoric of industrial policy under Giscard's presidency, particularly while Barre was Prime Minister (Cf. Nivollet 1983, 8-9). The information technology policy of the Left coalition government since 1981 also conforms by and large, in rhetoric as well as in practice, to the French tradition of industrial policy (Cf. on the latter, Shonfield 1965, 71-81). The new administration has linked the granting of subsidies to the newly-nationalized firms in the information technology industry to the conclusion of planning agreements (contrats de plan), in which the firms are required to set out their medium-term investment programmes and plans regarding, for example, research and development and vocational training (Cf. Nivollet 1983, supplement, 3-4). The five year programme for the electronics industry announced in July 1982 stipulated that the strategies of the individual firms in the sector were to be harmonised with guidelines defined by the state and that those of the nationalised enterprises were to be concerted, with production in the different sub-sectors of the industry being concentrated within only one or two firms (Cf. Ministere de la Recherche et de l'Industrie 1982c, 4).

Some statements by Fabius suggest that the firms in the industry may be allowed greater autonomy than is implied by the 1982 government programme (Cf. Fabius interview in Nivollet 1983, 39). Fabius stressed that the first priority of industrial policy had to be to define "clear rules of the game" for firms and then to stick to them and that the state had to create "a favourable climate for the development of the productive apparatus as a whole" (Ibid., 36-38).

intervention in certain sectors was necessary, but the state must not play around with structure of industry as if it were a meccano set (Ibid., 39). Certain state initiatives in 1982 and 1983, some of them taken already before the replacement of Chevènement as minister, correspond to this expressed desire to shift the bias of industrial policy in general towards more general instruments of intervention. In June 1983, the government announced a research and development tax-credit scheme under which the state would meet a quarter of the cost of any increase beyond previous expenditure levels of firms' research and development budgets. This followed the introduction of schemes freeing newly-founded firms from the obligation to pay local company taxes for the first three years of their existence and the creation of a special fund from which firms could receive cheap interest-rate loans for "modernising" investments, especially those involving the application of new technologies. However, the total sum of financial aid available to all industries under these programmes (Fr. 6.4 billion in 1984) does not equal that ploughed, on a selective basis, into the electronics industry (Cf. Section IV.1) Thus, selective policy instruments continue to predominate in French policy for the information technologies.

Detailed state intervention in industry has not enjoyed the same legitimacy in West Germany as in France. The relationship and balance between general and selective policy instruments have long been among the most controversial issues in West German technology policy. [19] Whereas the SPD has tended to opt for selective instruments to stimulate technological innovation, the Christian and (especially) the

Free Democratic parties, along with organisations representing business interests, have usually expressed a preference for general state measures designed to improve the general environment for entrepreneurial activity and avoiding state intervention in the decision-making autonomy of firms. The Christian-Liberal coalition government made the strengthening of general policy instruments one of its principal research and technology policy objectives (Cf. BMFT 1983, 3 and Riesenhuber 1983b).

The lion's share of federal state expenditure on research and development in West Germany has always financed selective, branch-based programmes, under which firms receive subsidies amounting on average (in 1980) to 57 per cent (in most cases to 50 per cent) of the costs of research and development projects which they propose themselves, but which must conform to more or less detailed guidelines laid down by the Research and Technology Ministry (Cf. BMFT 1982, 37). In 1974, the federal state spent just under DM 4 on such programmes for every DM 1 that it spent on 'indirect' programmes and in 1981 just over DM 4 (Ibid., 45 and BMFT 1983, 18). However, following the phasing out of special tax concessions for firms' research and development investments in 1974 (which altered this ratio from just under 4:1 to almost 12:1), the relative weight of 'indirect' programmes, measured in terms of state expenditure, rose once again, particularly with the introduction of state subsidies for the research and development personnel outlay of small firms under the Social-Liberal coalition government in 1979. The weight of indirect policy instruments was further strengthened by the Christian-Liberal

coalition's re-introduction of depreciation allowances for company research and development investments, so that the ratio of expenditure on direct instruments to that on 'indirect' policy instruments in 1984 shall be approximately 3:1 (own calculations from ibid.). The Christian-Liberal coalition has also retained the state subsidy for research and development investments which has run continuously since 1970 (Ibid. and BMFT 1979, 29).

With its 'production techniques' and 'micro-electronics applications' programmes, which were launched or planned already under the Social-Liberal coalition, the Research and Technology Ministry streamlined the criteria which govern the granting of state aid for firms' research and development projects with a view to simplifying and accelerating grant application and decision-making procedures. The demands which firms have to meet in order to obtain a grant under these so-called 'indirect-specific' programmes are also not as stringent or as tightly and narrowly defined as those for the normal selective programmes administered by the ministry. Otherwise, however, the 'indirect-specific' programmes do not differ from the selective ones. The programmes' 'indirect-specific' label serves rather to make them ideologically more palatable to the governing centre-right coalition and the business organisations in West Germany (BDI 1983).

Projected federal state expenditure on 'indirect' instruments of technology policy in 1984 totals some DM 1,081 million (£270 million), compared with a budget of 'selective' programmes for the information

technology industry of just on a half of that sum (DM 540.6 million, excluding the Post Ministry's contribution to telecommunications research and development). This means that the West German instruments of technology policy are much less strongly biased in favour of selective intervention in the information technology industry than the French. Given, however, that the former expenditure is strewn across the whole economy, rather than being targeted at a specific industry, the West German information technology industry still receives far more selective than general state financial aid.

Within the West German industry, the biggest firm, Siemens, is a strong supporter of the selective instruments of state policy. [20] Such instruments, according to the firm's research and development head, place "high demands on firms" and compel them to "increase their research and development outlay in areas of high risk" (Die Zeit, 5.8.1983, 16). General policy instruments, on the other hand, could be likened to a "technological ramble which serves primarily the health of the participants", without, however, offering "incentives to peak sporting performance" (Ibid.) However, most of the firms in the West German industry - which have not benefited to the same extent as Siemens from state grants for research and development projects - support a re-orientation of state information technology policy in favour of measures designed to improve the general 'climate' for entrepreneurship and research and development (Cf. Wirtschaftswoche, 9.9.1983).

The rhetoric of the Thatcher Conservative government in Britain

has been that the economic frontiers of the state should be rolled back to allow unhampered private initiative to develop and introduce technological innovations and create new wealth and jobs. Successive Secretaries of State for Industry have claimed that the Conservative government has no industrial policy. The government's philosophy, as stated by the Industry Secretary in 1984, Tebbit, is that "only the people who work in industry and commence can create wealth. What the government can do is help by ensuring that the conditions are right, that the framework is right, and that the tools are available to enable industry and commerce to get on with the job" (Department of Trade and Industry 1984, 1). While the government has taken numerous steps to improve the overall 'climate' for entrepreneurship (such as legislating to curb the power and rights of the trade unions), it has also expanded the selective intervention of the state in the British information technology industry. Most of the selective programmes, including those introduced by the Conservatives, offer subsidies for research and development, capital investment and feasibility studies covering a third of firms' costs. Certain programmes (such as those for software and telecommunications products) offer additional assistance for, for example, marketing. Programmes of financial aid for the British industry have been accompanied by other measures, such as an 'Information Technology Year' in 1982, to try to increase awareness of the potential applications of information technologies in industry.

Thus, on a scale of 'selectivity' of state information technology policy, Britain may lie between France higher up the scale and West

Germany lower down. There is no provision in the British programmes for the kind of detailed intervention in firms' decision making which takes place in France, but not as many general measures to promote technological innovation as in West Germany. In quantitative financial terms, however, selective instruments for the promotion of information-technological innovation are more significant for the firms in the industry than general policy instruments for technological innovation in all three states.

4. The role of the state as producer and consumer in the information technology industry.

This analysis of state information technology policies in France, Britain and West Germany has concentrated hitherto on the manipulation by the state of financial incentives, selective or general, for the promotion of information-technological innovation. However, the possibilities for the state to influence processes of technological innovation are not exhausted in its provision of financial rewards for 'innovating' firms. Of the other weapons from which governments may promise themselves an acceleration of the process of technological innovation, albeit less directly, the two most notable in these three states in the post-1974 period have been measures affecting the structure of property ownership and measures (on the demand side of the economy) to try to create a stable, secure market for the products of the information technology industry.

In France, the Left coalition government elected in 1981 saw in

an enlarged state sector the 'motor' of French industrial modernisation and technological adaption (Cf. Parti Socialiste 1981, 194-195 and Ministère de la Recherche et de l'Industrie 1982b, 4). In 1982 it carried through a major extension of the state sector in the economy. The now nationalised enterprises accounted in 1980 for some 52 per cent of all French industrial investment, employed 22 per cent of all workers in industry, and made 29 per cent of all sales of industrial goods (Blanc and Brulé 1983, 52). Before the nationalisations, the state's primary financial stake in the electronics industry was in CII-Honeywell-Bull, in which it took an indirect shareholding of 9.5 per cent when the firm was founded in 1976. The enlarged state electronics sector embraces not only CII-Honeywell-Bull, but also the two giant firms in the French industry, Thomson and CGE, and Matra, one of the principal manufacturers of integrated circuits, in which the state took a majority shareholding. Exactly a half of all production in the French electronics industry now takes place within state-owned or dominated firms. More significantly, from the point of view of technological innovation, the enlarged state sector accounts for well over a half of all French research and development expenditure in electronics (Projet de Loi 1983, 23).

The dominant position of the state sector within the French electronics industry is reflected particularly in the fact that privately-owned French firms accounted in 1981 for only 21 per cent of the output of the industry in france, while 30 per cent was produced by foreign-owned firms, such as IBM and Philips (Ministère de la

Recherche et de l'Industrie 1982a, 4). However, even before they were brought into the state sector, the big French electronics firms were, to a considerable extent, client enterprises of the state. State-owned banks could exercise some control over the supply of credit to the firms (Cf. Green 1984, 156). The giants of the electronics industry were among the principal beneficiaries of state financial aid to industry in general (Cf. Section IV.2). Moreover, the leading French firms in the industry had traditionally been favoured by preferential public purchasing policies (Cf. Section III). An innovation-oriented purchasing policy for French firms also constitutes one component of the Left government's electronics industry programme. When account is taken of the purchases of state owned firms, the state represents almost 50 per cent of the market for data processing equipment and office machinery in France - and is an even more important customer of the telecommunications branch (Cf. Truel 1983, 298). The French state has thus long had a wide-ranging arsenal of weapons to influence firms' decision making in the information technology industry. The nationalization of such firms as Thomson, CGE and Matra may not therefore have changed their relationship to the state quite as radically as might seem so at first glance. [21] None of the 'general' programmes to boost firms' research and development efforts or the small business sector in particular is likely to alter very substantially the prevailing distribution of state financial aid for firms' research and development work - of which, in 1980, some 84 per cent flowed to companies which now belong to the state sector. (Projet de Loi 1983, 23). The 1984 French budget provided for an increase in state aid to

state-owned industrial firms from Fr. 7.45 billion in 1983 to Fr. 12.85 billion - a far greater rise than that for state financial assistance to industry as a whole (Le Monde 16.9.1983).

Although the West German state has major shareholdings in a large number of firms in industry, commerce and banking, the information technology industry in West Germany is entirely privately-owned. [22] No major political force or movement in West Germany is in favour of an extension of the state sector into the information technology industry. While the state is not itself present as an entrepreneur in the West German industry, its instruments for influencing the research and development strategies of firms in the industry are not confined to the granting of aid for projects which conform to guidelines stipulated by the Research and Technology Ministry. All state research and development grants account, in any case, for no more than 14 per cent of the research and development expenditure of the industry (BDI 1982, 394-95). Excluding state grants for nuclear energy research and development, Siemens claims to have financed around 95 per cent of its research and development expenditure in the period from 1973 to 1982 out of its own resources (Die Zeit 5.8.1983, 16). On the demand side, in its capacity as a consumer of the information technology industry, the state possesses at least the potential to exercise a powerful influence on research and development in the new information technologies.

The significance of the state as a customer of the industry varies enormously, however, from one branch of the industry to

another. Of the output of the office machinery and data processing branch in West Germany in 1978, the state sector bought some eight per cent (Kreuz and Sprenger 1982, 18). For most telecommunications products, however, the Federal Post Office verges on being a monopoly consumer, buying between 80 and 100 per cent of the output sold on the domestic market (Ibid., 20). This is a consequence of the post office's monopoly of the provision and maintenance of the telecommunications network in West Germany. The post office, which does not itself engage in the production of telecommunications equipment, placed orders with industry in 1982 worth some DM13,500 million (Cf. Deutsche Bundespost 1982, 14). According to one source, one third of its orders, in value, goes typically to Siemens alone (Der Spiegel, no. 20, 1980, 114). The post office accounts for one third of Siemens' West German turnover and one fifth of its total turnover in the communications technology division of the company (Ibid.)

Uncertain expectations concerning prospective demand are one of the major factors deterring firms from making product innovations in Germany (Cf. Täger and Uhlmann 1983, 8 and, on Britain, Northcott 1982, 89). This might suggest that, by trying to develop a secure market for new products of the information technology industry through a co-ordinated purchasing policy, the state could speed up the process of information-technological innovation. However, the formulation of such a policy in West Germany seems not to have gone beyond the initial discussion stage. In the view of a former Research and Technology Minister, public purchasing in West Germany "is used only

seldom as an instrument for the selective promotion of research and development" (Von Bülow 1982, 3). This may be attributable to a number of factors: the federal structure of the West German state, which makes it difficult, in any event, to pursue a systematic, innovation oriented public purchasing policy; West Germany's aversion to protectionism, with which it might be charged if it were to pursue a too blatantly discriminatory public purchasing policy; the importance given to economy in public purchasing practices, especially in a period of growing state fiscal problems and increasingly austere fiscal policy; the code of practice for public purchasing, which attached primacy to economic, rather than innovation oriented, public purchasing; the attitudes and established practices of the civil servants in the purchasing divisions of state organs; and to the inhibiting provisions of West German competition policy which may forbid the pursuit of a co-ordinated public purchasing policy altogether. [23] The pursuit of an innovation-oriented public purchasing policy was among the demands made on the federal government by the informal association of firms in the information technology industry during the revision of state information technology policy by the Christian-Liberal coalition in 1983-84 and was indeed proposed in the information technology programme adopted by the coalition in 1984 (Wirtschaftswoche 9.9.1983, 24-26; Handelsblatt 30/31.12.1983; BMFT 1984a, 49-50).

In contrast to the Mitterand government, the Conservative administration in Britain has repeatedly sung the virtues of private ownership and the market as providing means of stimulating industrial

growth in general and expansion of information technology firms in particular. In order to stimulate the home telecommunications manufacturing industry, the British government first introduced liberalization measures in 1980. This permitted private suppliers to sell domestic telephone equipment, and permitted initially one private organization to provide a business telecommunications service. This is being followed up by current legislation to sell off 51 per cent of the shares in British Telecom, in order to remove it from the direct control of government and to encourage greater entrepreneurship (see Moon and Richardson, 1984b). The government has also sold its majority shareholding in Inmos and might also like to sell the British Technology Group (successor of the National Enterprise Board, the state holding company) to this end.

The British government, like its French and German counterparts, has displayed increased interest in mobilising public purchasing policy as an instrument for stimulating technological innovation. In 1980, the Department of Industry launched a 'Public Purchasing Initiative' which aimed "to use the purchasing power of the public sector to assist the efficiency and international competitiveness of its suppliers" and signalled the government's intention to use public purchasing more systematically to help promote innovation (Field, 1983). According to a recently published report, the state sector represents over 40 per cent of the British market for information technology products and service (NEDO 1982). Consequently, the state exerted a powerful influence on the shape of the industry at a formative stage (Ibid.). The pursuit of a co-ordinated, innovation-

oriented public purchasing policy is made difficult also in Britain by the multiplicity and varying degrees of autonomy of the purchasing agents (local government, nationalized industries and other quasi-state organisations, and the central government departments). [24] Nonetheless, preferential public purchasing practices have been used at least from time to time to support the British information technology industry - to prop up ICL in the early 1970s (Cf. Section III) and under the Conservative government since 1979 by the Department of Industry in its programmes to equip schools with computers (Moon and Richardson, 1984a).

In all three states, increased consideration is thus being given to the fashioning of public purchasing practices as an instrument of state policy for stimulating information-technological innovation. There is no doubt that, in the telecommunications branch at least, all three states have placed the great bulk of their orders with domestic suppliers, although their purchasing practices have not necessarily aimed consciously at stimulating technological innovation. The conditions for the systematic pursuit of an innovation-oriented public purchasing policy for the information technology industry appear more favourable in France than in either Britain or West Germany and it is here that such a policy seems most strongly to have been practised. [25] The role of the state as a creator of demand on the information technology market may, in turn, be stronger in Britain than in West Germany.

The future scope for the pursuit of a consequential innovation-

oriented public purchasing policy for the information technology industry in Britain may, however, be reduced by the Conservative government's policy of cutting back the state sector and creating more space for the 'free play of market forces'. The government's de-nationalisation of British Telecom means that the state will no longer be the near-monopoly consumer in the telecommunications market in Britain. From the 'rolling-back' of the state, the Conservative administration expects the same dynamic development of the information technology industry that the Left coalition government in France expects from its policy of extending the information technology frontiers of the state. In France, increased state financial aid for information-technological innovation has formed part of a strongly étatist strategy for the industry, whereas, in Britain, an increase in the volume of state aid for the industry has been flanked, since 1979, by other measures with a strongly anti-state-interventionist flavour. In contrast to both France and Britain, West Germany has experienced no political conflicts over the proper boundaries of the state sector in the information technology industry. In terms not only of the volume of state financial aid for the industry, but also of public purchasing practices and property ownership policy, West German policies for the information technology industry have, under successive governments, been less étatist and more 'market-oriented' than those pursued in France.

V. CONCLUSIONS

No major Western industrial state seems to be able nowadays to

get by without a policy and without an increase in the volume of state financial aid for promoting technological innovation in the information technology industry. Irrespective of changes of government, the ideologies of governing parties, the nature of the political culture, or the structure of the industry itself, the fear of a loss of international economic competitiveness arising through the failure to keep abreast of developments in what is regarded as a key future technology and the hope that the accelerated development and diffusion of new information technologies might stimulate economic growth and create new jobs have spurred all such states to intervene increasingly in the information technology industry and in the process of information-technological innovation. As this analysis of state information technology policies in France, Britain and West Germany however indicates, the scope and structure of state intervention varies very significantly. If no state can escape the 'information technology policy contagion', then such variables as national traditions or philosophies of industrial policy and party ideologies do shape the mode of state intervention.

Amongst these three states, state financial aid for the promotion of information-technological innovation is greatest and most selective and 'targeted' in France, where state subsidies have also been flanked by an extension of the state sector in the industry and - probably - by a more systematic innovation-oriented public purchasing policy favouring domestic firms than is practised in either of the other two states. From an initially very low level, in comparative perspective, state financial aid for the information technologies in Britain has

been increased very sharply since the late 1970s. At the same time, however, the Conservative government has also been concerned to cut back the role of state enterprise in the industry and laid great emphasis - although more in its programme than in its practice - on the improvement of the general conditions for private entrepreneurship in the information technology and other industries. State information technology policy in West Germany has been characterised by a higher degree of stability than that in Britain or France. This applies to the volume of financial aid to the West German industry (which has therefore fallen behind that provided by the British as well as the French state to their respective industries) and also to the role of state enterprise in the industry. The comparatively small magnitude of West German state aid for the information technologies, its less selective character, and the limited role of state enterprise, on both the supply and (except for the telecommunications branch) demand sides in the information technology industry and market are all pointers to the prevalence in West Germany of a more 'market-oriented' state policy than is the case at least in France. In both France and West Germany, and probably also in Britain, the distribution of state aid for the information technologies has been biased strongly in favour of a few, usually very large, domestic-owned or controlled firms. This pattern may alter, however, if state policies are gradually re-oriented towards promoting the <u>diffusion</u> of such technologies (their product-and process-applications) rather than their actual development, for which only very large firms may command the necessary financial and personnel resources. In West Germany, the introduction of the 'micro-electronics applications' and 'production techniques'

programmes possibly heralded the beginnings of such a process - which appears to be rooted in the growing recognition that the West Germans' (and possibly the Western Europeans') greatest deficit in the information technologies is not in their development, but in the speed of their diffusion and conversion into marketable products.

The fear among the advanced industrial states that a failure to make the information-technology 'connection' might lead to grave losses in international competitiveness, growth-chances and potential or existing jobs may be well-founded. The advanced industrial states which have experienced the highest rates of unemployment since 1968 have been those which recorded the lowest increases in productivity (and therefore, by implication, the slowest rates of technological progress) (Henize 1983, 40-43). It is highly improbable, however, that this phenomenon is attributable to varying rates of diffusion of the new information technologies, the potential for whose application is only beginning to be exploited in the advanced industrial states. One study has calculated that only five per cent of the scope for the application of micro-electronics had been exhausted by 1980 and projected that its rate of diffusion would not peak until the 1990s (Scholz 1982, 64). In 1982, for example, only 5500 industrial robots - far, far fewer than could potentially be introduced - were in operation in France, Britain and West Germany combined (Commerzbank 1983, 3). Our preliminary research suggests, however, that the proposition that the new information technologies represent a panacea for the employment problems of the advanced industrial states must be viewed with the greatest caution. This standpoint can be supported by

reference to employment trends in the information technology industry in Britain, France and West Germany since the middle of the 1970s. From these trends we ought to be able to deduce the extent to which information technology product-innovations create new employment. If the information technology 'revolution' is to exercise a noteworthy positive impact on employment, then this ought to be revealed by an examination of these trends, as it is widely expected that information-technology product-innovations will have a net job-creating impact, while process-innovations will tend to destroy jobs (Cf. Friedrichs 1982, 216-218; King 1982, 40-41; and Northcott 1982). This latter view is supported, for example, by the findings of Northcott and Rogers in their study of the impact of micro-electronics on British industry, although there are some sectors with a high level of actual or potential information technology application, such as banking and insurance, where employment has continued to grow (Northcott and Rogers, 1984).

In Britain, employment in the information technology industry declined at a rate of two per cent a year from 150,000 in 1975 to 123,000 in 1983. This decline took place despite an annual average output growth (in money terms) of 16 per cent (NEDC 1984, 3 and annex I). Significantly, a 23 per cent growth in production in 1983 failed to bring about any increase in employment. In France, employment in the electronics industry increased between 1975 and 1980 - but by only 12,000 (corresponding to an annual growth rate of only about 0.1 per cent) (Pastré 1983, 33). The picture is not very different when one looks at the West German information technology industry, which

increased its production more rapidly than both its British and French counterparts between 1975 and 1982 (Cf. NEDC 1984, annex II).

The two broad 'industries' (according to official statistical definitions) in which most information-technology product-innovations may be expected to take place in West Germany are the mechanical engineering (Maschinenbau) (including data-processing equipment) industry and the electrical engineering and electronics industry (elektrotechnische industrie). Throughout the post-1974 period, both these industries have, as a whole, remained extremely competitive on the world market. In 1982, the mechanical engineering industry earned a trade surplus of almost DM 50 billion (£12.5 billion) and the electrical engineering and electronics industry one of over DM 17 billion (£4.25 billion) (VDMA 1983, 46-47 and ZVEI 1983, 38-39). In a study of technological change and the labour market commissioned by the federal government in 1978, the conclusion was reached that these two industries would together prove to be the biggest net creators of jobs in the West German economy in the period from 1977 to 1990 (Prognos and Mackintosh 1980, 138-39 and 230-31). The number of jobs in the industries was forecast to grow by 520,000 (Ibid.). In fact, the number of employees in the mechanical engineering industry declined between 1977 and the first quarter of 1983 by 13,000 and in the electrical engineering and electronics industry (from 1977 to 1983 as a whole) by some 61,000 (VDMA 1983, 28; ZVEI 1981, 30; and Handelsblatt 9/10.3.1984).

These figures for employment trends in the mechanical engineering

and electrical engineering and electronics industries of course conceal a variety of conflicting trends within the different branches or product-groupings within the respective industries. Within those product-groupings or branches which are generally regarded as belonging to the information-technology industry, employment has in most cases risen. Despite massive increases in output, the overall number of jobs which has been created in these branches is, however, very modest. In the office and information-technology branch within the mechanical engineering industry, the number of employees rose between 1976 and 1982 from 64,400 to 78,754 - an increase of 14,354 or 22 per cent, while the output of the branch in the same period more than doubled (VDMA 1983, 205). The electrical engineering and electronics industry recorded in the same period moderate to massive output increases in the branches 'automatic data-processing' (which may be assumed to overlap with the 'office and information technology' branch of the mechanical engineering industry), 'communications technology', and 'semi-conductors' and 'electronic components'. In nominal value, the combined production of these three branches grew between 1978 and 1982 by 76 per cent. [26] Thanks largely to the communications technology branch, they earned a trade surplus of some DM 860 million in 1978 and DM 900 million in 1982 (ZVEI 1981, 36-37 and 1983, 36-37). The growth in employment in the branches - by 30,033 (or 16 per cent) from 187, 623 in 1977 to 207, 656 in 1982 - was far more modest than that in the branches' output (Cf. ZVEI 1981, 30 and 1983, 30).

The virtual stagnation, or even decline, of employment in the

British, French and West German information technology and electronics industries shows that the strong growth in the industries' output has been achieved primarily by massive increases in productivity (possibly spurred by the increased automation of the production-processes of the firms themselves). It is also clear that some new information-technology products have a high 'substitution' effect. Increased sales of word-processors or electronic typewriters, for example, may be matched by a commensurate decline in the production of mechanical typewriters, with no net positive employment effect. Not even employment trends in the American industry, which has increased its output much more rapidly since 1975 than any of its three Western European counterparts, nourish any hope that information technology innovation might make a substantial contribution to eliminating mass unemployment (Cf. Frankfurter Allgemeine Zeitung, 26.6.1984).

Thus, for the advanced industrial states that are tightly integrated into the international division of labour, the development and diffusion of the new information technologies may be a necessary component of a plausible strategy for combatting unemployment, or at least containing its growth. However, playing the information-technology card seems unlikely to make more than a very modest contribution to easing the levels of unemployment which prevailed in Britain, France, West Germany and the other major advanced industrial states in 1984. Indeed, consideration of the likely labour market impact of process-innovations stemming from the new information technologies might warrant the drawing of a more pessimistic conclusion.

FOOTNOTES

1. The other significant areas of application of information technologies are armaments (cf. Sections II and IV.1) and electronic consumer goods (electronic watches, video-machines, etc.). Together with the branches mentioned in the main text (data-processing, computing, and office machinery; communications technology, and automated manufacturing- and production-techniques), these branches are referred to collectively in this paper, according to West German usage, as the "information-technology industry" (informationstechnische Wirtschaft).

2. The term 'electronics industry' is used in the text where it, rather than the 'information-technology industry', was used in the original source. The two terms are probably interchangeable.

3. In Britain, for example, Margaret Thatcher has argued that Britain "must be up front in the new industries, the new products, the new services. For new technologies bring new opportunities... That's where new jobs come from" (Sunday Times, 27.3.1983). The Farnoux report on the electronics industry in France found that up to 200,000 jobs could be created in the French industry up to 1990 (Ministère de la Recherche et de l'Industrie 1982a, appendix 7, 2). The Research and Technology Minister in West Germany in 1982 argued that the restoration of full employment in West Germany in the 1980s could only be achieved by a restructuring of the economy through "new products, new technologies and new industries" (Frankfurter Rundschau, 18.1.1982).

4. Cf. For example, the view of the West German Research and Technology Ministry: "There is... no alternative to the utilisation of this technology (micro-electronics): branches and firms which use the new information components in production-techniques, and introduce them into products, too late will become uncompetitive; the loss of markets is a greater risk to jobs than... cut-backs in labour needs through technical rationalisation" (BMFT, 1979, 12). This opinion was also stated in the Farnoux report on the French industry. Cf. Ministère de la Recherche et de l'Industrie 1982a, appendix 7, 3.

5. Cf. On France, Parti Socialiste 1981, 193 and, on West Germany, Von Bülow 1981, 10-12; Handelsblatt 21.12.1983 and 20/21.1.1984 (for the views of CSU leader, Strauss, and Chancellor Kohl, respectively); for the views of a leading Social Democrat, Ehmke 1984, 17-18; and, for those of the Research and Technology Minister in the Christian-Liberal coalition, Riesenhuber 1983a, 7.

6. Cf. Section III and Ministère de la Recherche et de l'Industrie 1982a, appendix 7, 1-2, where the fear is stated that the United States or Japan could at some time in the future place embargoes on the export of micro-electronic components to France, affecting its defence capabilities if it did not preserve an independent components-producing branch.

7. Selective aid given to firms to stave off their bankruptcy is also excluded from consideration. The West German federal government, for example, guaranteed AEG securities worth more than DM 1 billion when the firm became insolvent in 1982.

8. McKinsey and Company (1984, section 4, 14-15) publish figures according to which some 48 per cent ($456 million) of government research and development spending on information technologies flows to the defence sector in France, 43 per cent ($492 million) in Britain, and 28 per cent ($202 million) in West Germany. However, they do not reveal how they arrived at these findings.

9. However, in contrast to the EEC statistics, the statistics of the West German Research and Technology Ministry depict a renewed rise in West German spending in 1981 (cf. Table two).

10. It ought to be noted that McKinsey and Company (1984, section 4, 14-15) reach very different conclusions on the volume of state spending on information technology research and development. They find that, among the three states dealt with in this paper, such aid is highest in Britain ($1145 million), with French aid amounting to $950 million and West German aid to $720 million. Excluding defence-related spending, the approximate totals are, respectively, $653 million, $494 million and $518 million. However, it is not stated how these figures were calculated or to which year or period they pertain (cf. also fn. 8 above). The totals do include some estimates of procurement-related government funding of defence and telecommunications research and development, but, again, it is not clear how these estimates were compiled. All the published official data on state spending on information technology innovation points to the conclusions reached in this paper - although these data, too, must be interpreted with considerable caution.

11. Federal government spending rose, in nominal values, from DM 582 million in 1982 to a projected total of DM 684 million for 1984. Cf. BMFT, 1984b, 118-20 and 126.

12. Unlike the West German figures, the British include spending (worth £61 million) on space research and development. Even excluding this spending, however, the volume of British expenditure will still exceed West Germany's in 1984.

13. Besse 1983 (241-42) refers to a study of the French finance ministry, according to which 56 per cent of all financial aid to industry went to just six industrial groups.

14. Calculations from BMFT 1981b, 426-95. As grants to universities and research institutes are included in the calculations, the proportion of aid to firms alone claimed by Siemens, AEG and Philips is significantly higher.

15. Figures from Probst 1983. Some DM 2,372 million of the aid received by Siemens was for nuclear energy research and development.

16. In 1979, some 56 per cent of all research and development expenditure by West German firms was carried out by companies with more than 10,000 employees. Cf. BDI 1982, 398.

17. In nominal values, federal government aid for research and development in small and medium-sized enterprises rose from DM 101 million in 1974 to DM 819 million in 1982. Cf. BMFT, 1984b, 77.

18. Note should be made of the regional aids available (most notably in the UK) for overseas firms in IT and other industries to set up factories in depressed areas e.g. Data Design of California received a £5M grant from the Industrial Development Board for Northern Ireland to take over and expand an indigenous 'printed circuit board' manufacturer.

19. The West German debate refers to 'direct' and 'indirect' instruments of technology policy. These terms are used here interchangeably with 'selective' and 'general' instruments, respectively.

20. Cf. Letter written by the research and development head of Siemens to the Research and Technology Minister, reported in Die Zeit, 5.8.1983. Siemens' preference for selective policy instruments is not surprising in view of the fact that, of the DM 4,211 million aid the company received from the ministry between 1973 and 1982, all but DM 500,000 was for research and development carried out under selective programmes.

21. Already in 1980, before the nationalisations, some 28 per cent of all research and development expenditure in the French electronics industry was financed by the state. Cf. Projet de Loi 1983, 21.

22. State-owned foreign firms, however, have production capacities within West Germany, especially the French company, Thomson, which bought up some parts of AEG in 1982-83, especially in the consumer electronics branch, in 1982-83.

23. On these points, especially those relating to the code of practice for public purchasing and West German competition policy, see Sprenger 1982, 9 and Kreuz and Sprenger 1982, passim., especially 20-21.

24. Of especial importance here is the Ministry of Defence, some 19 per cent of whose projected orders in 1983-84 were to be placed with the electronics industry (Miles 1983). In 1982-83, the ministry accounted for about 24 per cent of the turnover of the British industry.

25. On the framework for public purchasing in France, see Burkhardt and Heuschneider 1982, 36.

26. Calculations from ZVEI 1981, 16 and 1983, 16. Production, trade and employment trends in the consumer electronics branch are not considered in this analysis, as this is the sector in which the performance of the West German industry has been weakest.

TABLE ONE: STATE EXPENDITURE ON INFORMATION-TECHNOLOGY AND DEFENCE RESEARCH AND DEVELOPMENT IN FRANCE, WEST GERMANY AND BRITAIN, 1975 TO 1981

(Continued on next page).

Thousands of ECU	1975	1976	1977	1978	1979	1980	1981
FRANCE							
1) Electrical, electro-mechanical, electronic engineering	161,936	128,565	144,433	154,447	169,828	164,254	274,507
Including:							
a) Office machinery and data-processing equipment	105,334	54,604	57,955	66,343	83,370	35,611	76,822
b) Telecommunications equipment, electronic components, etc.	50,616	58,848	81,840	83,522	78,738	123,531	190,565
2) Telecommunications systems	76,813	79,753	101,533	105,282	113,218	127,791	140,730
3) Defence	880,280	858,088	1,061,349	1,306,657	1,603,926	1,933,903	2,466,917
WEST GERMANY							
1) Electrical, electro-mechanical, electronic engineering	82,360	79,190	86,481	95,459	99,784	66,575	53,900
Including:							
a) Office machinery and data-processing equipment	62,737	57,159	63,814	67,291	67,506	33,595	19,531
b) Telecommunications equipment, electronic components, etc.	19,622	22,031	22,667	28,168	32,278	32,981	34,369
2) Telecommunications systems	14	16	42	48	52	54	414
3) Defence	436,354	464,796	602,725	677,512	735,872	685,418	622,515

3) Defence 436,354 464,796

TABLE ONE/cont'd....

BRITAIN	1975	1976	1977	1978	1979	1980	1981
1) Electrical, electro-mechanical, electronic engineering	22,652	16,422	15,484	20,777	26,513	42,806	60,977
Including:							
a) Office-machinery and data-processing equipment	17,913	10,174	7,317	3,497	6,238	13,195	18,559
b) Telecommunications equipment, electronic components, etc.	87	5,910	6,679	5,888	10,133	11,952	28,506
2) Telecommunications systems	1,236	1,322	86	184	388	571	1,087
3) Defence	927,086	1,106,051	1,265,312	1,321,909	1,675,745	2,244,838	3,120,191

Sources: Commission of the EEC, 1976, 116-121; 1977, 100-105; 1978, 146-151; 1980, 168-173; 1981, 172-177; 1982, 178-181; 1983, 218-222.

TABLE TWO: FEDERAL STATE EXPENDITURE ON INFORMATION TECHNOLOGY RESEARCH AND DEVELOPMENT IN WEST GERMANY, 1974-1982

Millions of DM	1974	1975	1976	1977	1978	1979	1980	1981	1982
Micro-electronics	60.8	56.1	58.1	74.5	82.7	110.2	106.2	116.6	240.0
Data Processing	343.5	370.3	330.1	280.5	268.6	271.7	147.2	140.8	107.9
Telecommunications	54.7	62.6	63.7	71.3	83.5	113.6	129.3	164.7	224.0
Automated Manufacturing	32.6	39.5	34.2	40.2	45.3	39.8	39.3	40.1	47.0
TOTAL	491.6	528.5	486.	466.5	480.1	535.3	422.0	462.2	618.9

Source: BMFT 1982, 77-82. All values are nominal. The figures for 1981 are estimates and for 1982 projections. According to more recent, uncategorised expenditure figures published by the Research and Technology Ministry (BMFT 1984b, 118-120, 126), DM 455 million was actually spent on information technology in 1981 and DM 582 million in 1982. The projected spending volumes for 1983 and 1984 were, respectively, DM 639 million and DM 684 million.

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